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COLONIAL DEVELOPMENT AND WELFARE

THE Colonial Development and Welfare Bill, proposing to increase from £120 millions to £140 millions the sum that may be spent on Colonial development and welfare to the end of March 1956, and to raise to £25 millions the limit on the expenditure on development in any one year, which received a first reading on November 1, indicates the importance which the Government continues to attach to these purposes. The recently issued Return of Schemes under the Colonial Development and Welfare Acts, April 1, 1949, to March 31, 1950*, shows the magnitude of the demand which some of these developments are already making in the scientific field alone. For that reason, some recently issued papers are of interest to scientific workers concerned with such developments by enabling them to appreciate the general background against which the value of the scientific effort required has to be assessed and its expenditure justified in relation to competitive demands.

The report and accounts of the Colonial Development Corporation for 1949 are indeed mainly of commercial interest, but some of the reports of the commercial and technical divisions will interest scientific men. That of the Agriculture Division, for example, points out that, in view of the grave damage caused to the West African cocoa areas by swollen shoot disease, consideration has been given to the possibility of establishing cocoa in other areas, and two small projects have already been approved, one for Malaya and another for British Honduras. Projects for planting oil palms and coconuts are under consideration, and certain oilseeds are included in the cropping programme of the Corporation's agricultural undertaking in Northern Nigeria.

The Corporation has also given much attention to the possibilities of fibre production, especially the production of jute and jute substitutes. With one exception, jute trials carried out in various parts of the world under other auspices have been unsatisfactory, and on the whole the Corporation considers that the possibilities for substitute fibres are greater than those for jute, at any rate in the Colonies. Although four jute substitute fibres have shown promise for sack manufacture, the chief problem is that of finding a suitable decorticating process to replace the traditional methods of retting by soaking in water, which are expensive in man-power and involve a distasteful form of work. The Corporation is also investigating several processes which may extend the use of ramie by providing technically satisfactory and economical methods of decorticating and especially of degumming.

The report shows clearly that the Corporation is steadily and systematically acquiring the scientific and technical knowledge on such matters as soils, the performance of particular crops and the incidence of disease, the techniques of large-scale cultivation and

* Colonial Development and Welfare Acts. Returns of Schemes made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies, with the concurrence of the Treasury, in the Period from 1st April 1949 to 31st March 1950. Pp. 73. (London: H.M. Stationery Office, 1950.) 1s. 9d. net.

of the clearance of large tracts of virgin land, often covered with the most recalcitrant types of vegetation, upon which alone sound development can be based. Besides this, however, the report discusses the broad questions of external relations and the factors that determine, for example, the possibilities of American investment in the Colonies, the costs of Colonial development undertakings, markets for Colonial produce and the Colonial economic background. The indispensable foundations of development must be the provision of ports, roads, and railways, schools and hospitals. These fall within the sphere of Colonial government finance, assisted by the Colonial development and welfare funds. Upon this basis must be built the agricultural and industrial activities which will raise the level of production, living standards, and exports, partly by way of new undertakings, partly by the reinforcement, technical and financial, of existing enterprises, and partly by the progress of indigenous producers in modern techniques.

Compared with the Overseas Food Corporation, the Colonial Development Corporation's advance is cautious. The twenty-eight undertakings started by December 1949 represent an authorized capital of £14,000,000, ranging downwards from the £3,750,000 for the Malayan Electricity Board; but only a quarter of this sum had then been spent. But even more important than this financial assistance may well be the contribution which the Corporation is making to the economy of comparatively undeveloped countries by raising to a higher level the skill and enterprise of their peoples.

This aspect depends so largely on the establishment of conditions of mutual respect and understanding and co-operation that it is of the utmost importance that there should be clear and widespread public understanding in Great Britain of the conditions which determine Colonial development and welfare, and the way in which they react on affairs in Britain. Although territorially their scope is more limited, two other recent reports, from the Colonial Office, are even better fitted to perform that educational function. The first of these, the annual report of the East Africa High Commission for 1949*, not only provides a clear account of the evolution of the Commission and of the work of its first year, but also a most valuable survey of the organization of the joint research and scientific services of that area, against which the significance of the various research schemes detailed in the Return of Schemes made under the Colonial Development and Welfare Acts can be appreciated.

The mere list of inter-territorial scientific services which the High Commission has administered since its establishment is impressive. To these were added in 1948 the East African Railways and Harbours Administration and the East African Literature Bureau, and in 1949 the East African Customs and Excise Department. On their formation the East African Information Office, Radio-communications Service, Regional Geological Survey and Topographical Survey will also be administered by the High Commission, as well as such further research services as are set up on an East African basis. Furthermore, besides the amalgamation and conversion of certain scheduled services, and the formulation of High Commission regulations, the work of the past year has included the introduction of special terms of service for research workers, and much progress has been made in the siting, planning and construction of headquarters of research organizations. The East African Bureau of Research in Medicine and Hygiene, the Filariasis Research Unit and the East African Medical Survey were established during the year, while a reconnaissance survey in the three territories of agricultural and animal research, disease control and soil conservation, made by a team of widely experienced American agricultural research administrators, Drs. Lambert, McCall and Clyne, gave the Economic Co-operation Administration and the United States Department of Agriculture a clear idea of the type of research needed and the type of American specialist who would be of most benefit to the territories.

It is hoped by this means to accelerate research concerned with the general development and well-being of the peoples of Africa and the neighbouring territories. The need for additional personnel, material and equipment which cannot at present be supplied by the United Kingdom was assessed, and detailed schemes are being worked out; meanwhile, the fifth chapter of the report shows how great an advance towards inter-territorial co-operation in research and scientific services has been made since Lord Hailey's "African Survey" appeared. Under the East African Agriculture and Forestry Research Organization, for example, the fertilizer experiments team and the closely associated team under the Kenya Agricultural Department have continued the extensive series of fertilizer trials that began in 1947, and have provided strong evidence that the so-called 'soda-phosphate' manufactured from the Uganda rock-phosphate deposits is less effective, weight for weight, than the imported triple superphosphate. Further factors are being investigated. On the strength of the circumstantial evidence provided by the Clove Research Scheme that the 'sudden-death' disease of cloves in Zanzibar is a virus disease, a scheme for the control of the disease on Pemba Island by a policy of swift and systematic eradication of outbreaks has been approved; this scheme, however, is at present under reconsideration owing to further evidence that the disease is so much more widespread than had been assumed that the chances of effective control throughout the affected areas by this means are slight.

Towards the end of the year, it was decided to establish as rapidly as possible all central activities of the East African Veterinary Research Organization on an appropriate site in the Muguga Forest Reserve, where an area of about 900 acres is being made available by the Government of Kenya. These activities are to include the long-range research on animal disease and the manufacture of biological products, which was to have been located at Kabete. A start has been made on the study of the bovine pleuro-

* Colonial Office. Annual Report on the East Africa High Commission, 1949. (Colonial No. 263.) Pp. ii+40+4 plates. (London: H.M. Stationery Office, 1950.) 1s. 6d. net.

pneumonia organism in the developing egg with the view of determining whether the chick embryo will serve as a laboratory animal, while in consequence of the research on 'Antrycide' which has indicated that acquired resistance is easily developed and that the period of apparent protection is considerably shorter than was suggested by early experiments, greater emphasis will be placed on further investigation of the curative value of the drug.

The scheme for the establishment of a Central Trypanosomiasis Research Institute at Serkulu, Uganda, is progressing, and special attention is now being paid to evolving new methods for the study of the relationship of the tsetse to its environment, particularly local climate. Valuable information on anti-tsetse measures has been obtained in the Nyanza province of Kenya, where problems of reclamation concern *Glossina palpalis* and *G. pallipedes*, at Mbarara, Uganda, and in the Jringa and Tabora districts of Tanganyika. A particularly encouraging feature of these inter-territorial experimental reclamation schemes is the finding that *G. morsitans* is often—and *G. pallipedes* is sometimes—concentrated in relatively narrow inter-zones of vegetation associated with topography, and that bush-clearing in these strips alone has a significant effect on the fly population. Recent work in the new tsetse areas seems to confirm the original findings of the workers from the Imperial Chemical Industries, Ltd., but elsewhere there have been varying results in experiments with 'Antrycide' as a prophylactic drug for enabling herds to be established in fly-infested areas, and more intensive research directed to curative effects and toxicity has been recommended.

The main fishery research effort has now been diverted from *Mormyrus* to *Tilapia*, and results already obtained indicate the possibility of greatly developing this particular fishery, which is the most valuable one on Lake Victoria. The research includes studies on growth, breeding and feeding, and the sex ratios of the various populations, and an attempt is being made to follow both the horizontal and vertical migrations of these fish. A brief account of the major investigations pursued by the East African Industrial Research Board on ceramics, phosphate fertilizer, building materials and pyrethrum during 1949 is included. No organized research programme in meteorology was possible during the year. The work of the Desert Locust Survey was seriously disturbed by the appearance of swarms first, in February, in Oman, and then, in May, in the Aden Protectorate, the Yemen and south-west Saudi Arabia. During the period of alarm, the Survey's officers watched the danger areas, with the exception of the Yemen, and, as a result of an international conference in October at Karachi, India, Iran and Pakistan strengthened their control organizations, and it was agreed that strenuous joint efforts should be made to control locusts in Oman. Besides having to mount these control measures and send missions to the sands to study the conditions which led to the threat of the new plague, towards the end of 1949 the Survey was faced with the prospect of having to watch the coasts of Aden, Yemen, British Somaliland, western Saudi Arabia and Eritrea for incipient swarm breeding. The whole of its plans have thereby been altered; but the importance of inter-territorial organization and co-operation has simultaneously received a dramatic vindication.

Of the medical research side, no more need here be mentioned than that the Filariasis Research Unit formed on June 1, 1949, is endeavouring to ascertain how serious the problem is to the economy and welfare of East Africa, and is investigating methods of control and treatment, either by the use of drugs, such as 'Hetrazan', or by control of insect carriers or both. The headquarters of the East African Medical Survey were moved to Muranza, Lake Province, in October 1949. It is the aim of the Survey to obtain a picture of the health of the African, and to obtain information on how best to control the more important of the commoner diseases of East Africa.

The second of the two reports, that on "The British Territories in East and Central Africa, 1945–1950"*, is even more valuable as providing the background information against which the significance of all these developments can be appreciated. Although this report nominally covers the five years since the end of the War, it can fairly be claimed that it presents a balanced picture of the achievements of British administration in East and Central Africa over the past half-century. The chapters dealing with reconstruction and development, with research and surveys, with the development of natural resources, and with education—indeed, the whole of its nine chapters—can be read with interest and profit by all who, whether scientific men or not, are interested in Colonial welfare and development, and are anxious to form an independent judgment, not merely on the merits of particular schemes but also on the question of the comparative pace at which political and economic development is possible. The objectives of political and economic development are both made plain, and whatever opinions may be held about the pace of progress it is clear from these pages how anxious are the British authorities to secure that all such advance is based firmly on the understanding and support of whatever traditional or representative authorities exist among the African peoples, whether at local or national level.

The information on research and surveys in this report does not, except in one or two small points and the time period covered, add much to that contained in the report of the East Africa High Commission. There is a reference to the promising results obtained in the active pursuit of research on rabbit-adapted rinderpest virus, and to the work of the Colonial Insecticides Research Unit at Arusha, Tanganyika. Attempts are being made by means of experiments with group farms to devise new farming systems, capable of general adoption, which will ensure that the land is more scientifically and more efficiently worked than under the haphazard distribution of the land under traditional systems of land tenure. Further, an inter-territorial East African Scientific and Industrial Research Board has

* Colonial Office. The British Territories in East and Central Africa, 1945–1950. (Cmd. 7987.) Pp. iv+166. (London: H.M. Stationery Office, 1950.) 4s. net.

been set up to take over the work of the East African Research Board. There are comments on Makerere College, on the supply of teachers, on technical and specialist education and on the expansion of medical services.

The record of achievement in the whole Colonial field is an impressive one; but there must be no slackening of effort, scientific or administrative. Rather must the pace be increased, for no policy of 'safety first' can be either possible or acceptable to the Colonial peoples whose political aspirations have been aroused.

THE THEORY OF LIQUIDS

A General Kinetic Theory of Liquids

By M. Born and H. S. Green. Pp. vii+98. (Cambridge: At the University Press, 1949.) 10*s.* 6*d.* net.

THIS publication in book form of five papers on the Born–Green theory of liquids, together with a paper describing a kinetic-theory derivation of the thermodynamics of a 'quantum' assembly, is very welcome. Many attempts have been made to treat liquids and solutions by statistical mechanics, and specialized models can deal with particular problems; but the total result has been decidedly scrappy. Born and Green have approached the field from the point of view of kinetic theory, bringing to it both freshness of outlook and considerable insight.

The new methods introduced and some of their results, particularly those in the paper on thermodynamics (Chapter 5), represent definite contributions to knowledge, but I feel that the authors have overplayed their hand in some of their claims. An example of such an exaggerated claim is the suggestion (p. 23) that their fundamental integral equation may have spatially periodic solutions which represent the solid state. Since the integral equation has been derived on the basis of the so-called 'Kirkwood approximation' (equation 4.6, p. 5), which cannot possibly be valid for a spatially periodic lattice (although it is probably very good for a liquid well above its freezing point), this claim is at least premature (unless it can be shown that the equations still possess this type of solution even if the 'Kirkwood approximation' is not made). As it stands, the theory cannot hope to describe more than the gaseous and part of the liquid regions.

Papers 1 and 2 derive the equilibrium properties of a 'classical' liquid, the 'Kirkwood approximation' playing a vital part by enabling the infinite series of differential equations, to which the general theory leads, to be replaced by an integral equation involving the distribution function $n_2(r_{12})$, which equation can be solved if two further approximations (discussed in the notes) are made. The result is a theory very similar to the Mayer theory of condensation, explicit expressions for the 'cluster integrals' being obtained, and, in addition, it is known that the equilibrium properties of a liquid are all obtainable from a sufficiently accurate expression for $n_2(r_{12})$ as a function of density and temperature. It is concluded that the change-over from the vapour to the liquid phase is associated with a branch-point in the free energy. This conclusion, if true, represents a definite improvement on the Mayer theory, where the nature of the singularity is left in doubt on account of the uncertainty in the behaviour of the cluster integrals. It must, however, be remembered that the work of Onsager[1] has proved that the nature of the thermodynamic singularity associated with a particular physical model can be obscured or modified by an approximate treatment, even if the approximations themselves seem quite plausible physically.

Both forms of the theory, classical and quantum, seem to be equivalent to the following model. The interaction between two typical molecules is considered explicitly, while the effect of the remainder is represented by a 'smoothed' field about which very little need be assumed. Strictly, this means that one is calculating a distribution function proper to a gas moving in a potential field rather than to a liquid, but the approximation probably involves little error except just above the freezing point. The model is certainly an improvement on the 'cell' model of a liquid, in which just one typical molecule is thought of as moving in a smoothed field representing the others.

Paper 3 represents an attempt to derive expressions for the viscosity and thermal conductivity of a 'classical' liquid. An approximate formula for viscosity, similar to Andrade's, is obtained, and it is claimed that the two coefficients can be predicted exactly if the interaction between the molecules is supposed to be known. Preliminary details of such a calculation are given; but the amount of work needed to complete it in an actual case looks prohibitive.

I have been able to make little or nothing of this paper, having found it impossible to rescue the physics from the morass of mathematical symbols and complicated equations. Just two such difficulties may be mentioned. The notation used is so complicated that, despite much searching, I found it impossible to verify that the definitions of viscosity and thermal conductivity (pp. 38 and 39) agree with the standard ones. If these verifications are available elsewhere, the references should have been given. The other difficulty is that I was unable to find, in this paper, any discussion of the well-known paradox that the equations of mechanics, and therefore any equations derived from them, are reversible in time. As pointed out by Kirkwood (1946), this paradox can only be resolved by taking account of the fact that any actual experiment occupies a finite time which is long compared with some of the time-intervals associated with an assembly (for example, the time between atomic collisions) and short compared with others (for example, the Poincaré period of the assembly). In practice, a sharp division of the time-intervals into 'short' and 'long' can never be made, and some of the relevant time-intervals will be comparable with whatever time one takes over an experiment, this being a sign that 'thermodynamically irreversible' effects are occurring. Any acceptable theory of an irreversible process must include a discussion on these or similar lines. Its apparent absence in this paper is surprising in view of the penetrating discussion of the analogous question of the quantum-mechanical H-theorem in Chapter 5.

Chapters 4 and 6 (Papers 4 and 5 in the published series) extend the above considerations to a quantum-mechanical assembly. The equations of hydrodynamics are found to be formally valid for a quantum assembly provided that one recognizes two distinct definitions of temperature and pressure, which are equivalent for a classical assembly but differ for the quantum-mechanical one. This contention is cer-

tainly correct so far as temperature is concerned, it being possible to define temperature either in terms of the macroscopic properties of the assembly (thermodynamic temperature) or in terms of the distribution of velocities of the molecules (kinetic temperature). These two definitions are certainly identical in any classical assembly (whether the molecules interact or not) but will differ in all but very special quantum-mechanical assemblies. Green is on much more dangerous ground in claiming that a similar situation exists for the pressure. Two apparently different definitions of kinetic and thermodynamic pressures can indeed be given, but various authors claim to have proved them equivalent. Although it is clear that some of these 'proofs' are invalid, it nevertheless seems likely that the two definitions are equivalent. The reader is referred to a paper by Price[2] for a bibliography and a careful discussion of the controversy. (Two further papers have appeared[3,4] since this was written.)

Green attempts to apply the existence of the two pressures to an explanation of the thermo-mechanical effects and the propagation of 'second sound' (thermal waves) in the low-temperature modification of liquid helium. He rejects what is usually known as the 'two-fluid theory' (the phenomenological assumption that liquid helium II can be regarded as a solution or mixture of two fluids, only one of which possesses viscosity) on the ground that it leads to "physically absurd conclusions" (though no example is given). He ignores the undoubted success of the two-fluid conception in unifying a considerable body of experimental evidence (capillary-tube and oscillating-disk measurements of viscosity, fountain effect and heat-transfer, propagation of second sound), which strongly indicates that it has some physical basis, and Green's theory itself leads to very similar predictions.

Even granting the existence of two distinct pressures, I consider that Green again overplays his hand in not only claiming to be able to explain, in principle, all known properties of liquid helium, but also in holding out hope that the theory can be applied to superconductivity "with slight changes". As an example of properties of liquid helium which clearly cannot be explained on the 'two-pressure' basis alone may be mentioned the 'creep' phenomena of liquid helium films. It is possible, for example, to observe the 'creep' phenomenon occurring at a finite velocity between two vessels of liquid helium II in the absence of any measurable pressure or temperature differences between the two ends of the film. No indication at all is given of how, with or without the 'two-pressure' hypothesis, Green is going to explain either the destruction of superconductivity by a magnetic field or the Meissner effect (expulsion of magnetic field by a superconductor).

Chapter 5 contains a very interesting discussion of the quantum-mechanical H-theorem. Green considers a general assembly perturbed by some external agency. He shows that a function can be found, equivalent to entropy of the assembly, which can only increase with time, and attains its maximum value when all the states which the assembly can occupy are filled as evenly as conditions permit. This result holds only if terms higher than the second order in perturbation theory are omitted. The inclusion of these higher terms implies that the assembly fluctuates about its mean configuration and thus, given a sufficiently long time, would attain a configuration as far from the mean as that in which it began. Green suggests that this provides a new means of studying fluctuation phenomena. I agree, and consider that this paper represents a definite advance in a very difficult field, the average text-book discussion of this type of problem being unsatisfactory.

The book is well printed and produced. It has only been possible, because of the nature of the reproduction process, for the authors to make minor alterations in the text and to add a few 'second thoughts' in the form of notes. It is a pity that the opportunity to add a list of symbols was not taken.

H. N. V. TEMPERLEY

[1] Onsager, L., *Phys. Rev.*, **65**, 117 (1944).
[2] Price, P. J., *Phil. Mag.*, **41**, 948 (1950).
[3] Riddel, R. J., and Uhlenbeck, G. E., *J. Chem. Phys.*, **18**, 1066 (1950).
[4] Green, H. S., *J. Chem. Phys.*, **18**, 1123 (1950).

STATISTICS FOR PSYCHOLOGICAL EXPERIMENTS

Experimental Design in Psychological Research

By Prof. Allen L. Edwards. Pp. xv+446. (New York: Rinehart and Co., Inc., 1950.) 5 dollars.

THE problems of experimental design in psychological research are many and varied. With a legitimate desire for objectivity and purity of scientific approach, the psychologist has begged, borrowed or stolen statistical devices originally designed for other fields of research. Some such borrowings have met with success. Others, however, leave the doubt that their fundamental assumptions are incompatible with what can be surmised about human behaviour in the experimental situation. Repetition of varying but nearly similar tasks by one subject can lead either to 'learning' or to 'boredom', or a mixture of both. There is no way of telling beforehand how the subject will respond in this matter. To describe it as a change of motivation may be descriptive psychology; but a significantly small order of trial variance in a standard Latin-square design is always disturbing. Similarly, to formulate a null hypothesis based on independence between trials is to postulate what the results might have been had the subjects not been human. There is some evidence further which suggests that rats feel the same way about experiments. The research psychologist is therefore often faced with a choice: either he keeps the psychology right, and produces an untidy and statistically inelegant experiment; or he keeps his statistics and hopes the psychology will only come out in the right places.

This is an unsatisfactory state of affairs, and it is with raised hopes that one reads the title "Experimental Design in Psychological Research". The hopes do not survive the table of contents. The book is one more elementary statistics text, with a concession to psychology in that the illustrative material is drawn from psychological sources. There are many other elementary statistics text-books, some better, some worse. The research worker's choice is probably dictated by predilections for order of presentation, number and nature of examples, clearness of text, or references to original work. This book is neither outstandingly good nor outstandingly bad in these things. Some conventions are followed which seem odd to the English reader. Numbers in the text are always given as numbers—"after the rat has learned the discrimination of the 2 squares it is given a series of 8 trials with 2 circles". Pages set

out in this fashion are disturbing to the rapid reader searching for a particular problem.

With regard to specific contents of the book, the chapter "Probability and Experimental Design" starts off with the use of the binomial expansion, well presented although no correction is suggested to deal with the discrete values. The normal distribution and χ^2 distribution are then introduced as approximations. The Poisson distribution is not mentioned, although Bartlett's square-root transformation is given for data recorded as number of errors per trial. A welcome intrusion is the mention of the hypergeometric treatment of the fourfold table, even though it is wrongly attributed to R. A. Fisher; but E. S. Pearson's approximation which so increases its practical value is not mentioned. Treatment of analysis of variance is along fairly conventional lines, and a great deal is said of factorial designs. Regression makes a brief appearance in the all too brief chapter on analysis of co-variance. Given the psychological emphasis, it is surprising that no mention is made of ranking statistics. The statistical tables are good, and Prof. Edwards is also to be congratulated on condemning, by omission, multiple correlation and factor analysis, twin pitfalls for psychologists with a taste for computation. J. W. WHITFIELD

PREHISTORY AND ARCHÆOLOGY OF ANGOLA

Some String Figures from North-East Angola
By M. D. and L. S. B. Leakey. Pp. 24.

Museu do Dundo, Publicacoes Culturais No. 1
Stations préhistoriques de l'Angola du Nord-Est. Analyse géologique, climatologique et préhistorique d'un sondage fait en bordure de la rivière Luembe (Angola du Nord-Est). Par J. Janmart. 2ª edicao. Pp. 88.

Museu do Dundo, Publicacoes Culturais No. 2
La station préhistorique de Candala (District de la Lunda, Angola du Nord-Est) e outros estudos sobre prè-história da Lunda, por Jan Janmart. As gravuras rupestres do Alto-Zambeze e primeira tentativa da sua interpretacao, por José Redinha. Pp. 92.

Museu do Dundo, Publicacoes Culturais No. 5
Les limons et graviers de l'Angola du Nord-Est et leur contenu archaéologique. Par Prof. Henri Breuil et Jean Janmart. Pp. 57.

(Lisboa: Companhia de Diamantes de Angola, 1949, 1947, 1948 and 1950.)

ONCE again the Companhia de Diamantes de Angola and its "Chef du Service de Prospection", J. Janmart, and his colleagues have put prehistorians in their debt. The first work is great fun and for it we have to thank Dr. L. S. B. Leakey's indefatigable energy which drove him to look for something to occupy his time during a period of wet weather. Among many primitive peoples string figures play an important part, and it is delightful to have a fresh series so well set out.

The second and third works (Publications Nos. 1 and 2) must, of course, be taken with the companion volumes by Dr. Leakey and the Abbé H. Breuil. The region that is now Angola played an important part in prehistoric times. During dry periods when semi-desert conditions existed in many areas of South Africa, the rivers in Angola continued to flow and migrations into the area took place. The opposite happened when the climate changed and damp conditions set in. Angola then became a cradle area whence cultures flowed out eastwards and southwards.

The Museu do Dundo Publications Nos. 1 and 2 contain important information for the student. The former is concerned with the finds from a large number of sites. The reader may be slightly confused by the use of such terms as Kalinian (cf. Lower Sangoan and Fauresmith) and Djokocian (cf. Upper Sangoan) which are current in the Congo. But there will be little real difficulty in correlating the finds with known cultures elsewhere, and the illustrations are helpful. The second volume deals in greater detail with a particular site. The geology and archæology are both considered. The section on the rock-engravings of the Upper Zambezi is written in Portuguese; but is not difficult to follow. The art is entirely geometric and consists of a series of complicated patterns, the simplest being a series of concentric circles, knots and a number of wheel-like figures with spokes. Why these elaborate figures were made is unknown. There is no doubt that, prehistorically speaking, Angola has been recently very much 'put on to the map'.

As regards the last work here under review (Publication No. 5), only recently a similar volume on the "Stone Age in Angola" appeared under the auspices of the Companhia de Diamantes de Angola from the pen of Dr. Leakey. The present publication deals particularly with the industries and their succession. It is of capital importance both now and for any further work in this part of Africa. It starts with a study of some fractured material of very early date, and the suggestion is put forward that, from analogy with exactly similar phenomena known in Europe, these fractures must in all probability be due to glacial action. A glaciation in Angola at any geological period is an interesting thought, and further study will be needed before any certainty can be claimed for the hypothesis. Coming to Quaternary times, the gravels from a series of terraces are passed under review and the implements found in them examined. An excellent section across the valley of the Lunda makes it clear what the authors are considering. There follows a discussion of certain rather later loams and their archæological contents.

The volume concludes with a more detailed account of the industries from a number of selected sites, which include what are described as Abbevillian and Acheulean coups de poing, cores of Levallois technique, a flake "en chapeau de gendarme" and implements of a variety of stages of the Kalinian (Sangoan) culture. The work is to some extent complementary to that by Dr. Leakey, and the two of them lay the foundations of the subject in the country. The only criticism which can be levelled against the present one is the poorness of the drawings. There are some excellent photographs which have no more than the usual limitations of photographic reproductions of stone implements, but in the drawings a genuine attempt has been made to depict exactly what the stones look like—as if they had been photographed—whereas it would have been more helpful to have indicated more clearly how the objects had been fashioned. The authors are to be congratulated on an excellent piece of work.

M. C. BURKITT

EARLY HISTORY OF QUANTUM MECHANICS

By Prof. L. ROSENFELD
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TO inquire into the early stages of development of a scientific theory is no idle curiosity. Indeed, no adequate appreciation of its present state is possible if the various aspects which have gained prominence in the course of time are not traced back to their roots. This is especially true for the quantum theory of atomic systems, which presents such unfamiliar features and has led to such far-reaching conceptions as Niels Bohr's idea of complementarity. The history of quantum mechanics is, in fact, particularly instructive as an illustration of the inherent logic of the growth of scientific ideas. At the same time, it is not lacking in dramatic surprise: it forcefully reminds us that a vigorous flight of imagination can sometimes unexpectedly quicken the pace of a more methodical progress.

It would be futile to try to date the birth of quantum mechanics from a particular discovery, or to relate it to a particular name. The creation of this imposing doctrine has been a work of patient and gradual approximation to the truth, and it is the result of collective—if sometimes unconcerted—efforts. Nevertheless, it is possible to point to one inspiring idea, which gave the whole development unfailing guidance: it is Bohr's principle of correspondence, or (as he prefers to call it) correspondence "argument". This last word serves to emphasize the fact that we are concerned not with a definitive, well-polished formulation of a natural law, but with a general point of view useful in the orientation of the search for unknown regularities of atomic systems. The young physicists who nowadays solve wave-equations as a matter of routine are not always taught how essential the correspondence point of view remains for the physical interpretation of the new formalism. Still less can they realize how essential an instrument it has been in the pioneering period of elaboration of this theory.

Bohr's early work was taken up, in the early 'twenties, with characteristic thoroughness and energy by the flourishing German schools of theoretical physics, clustered around the figures of Sommerfeld and Born. Munich and Göttingen not only became active workshops in which the properties of multiply periodic mechanical systems and their quantization were explored in all directions, but also at the same time yielded year after year a vigorous crop of brilliant young men, fascinated by the adventurous quest and fully equipped for it.

In the meantime Bohr himself, with fewer but no less able disciples, pursued his equally thorough and, doubtless, more penetrating investigations. Much of his work in those years was never published; but, at any rate, it inspired his close collaborators. The *leitmotiv* of Bohr's profound analysis of the quantization of multiply periodic systems was the underlying correspondence between quantal and classical behaviour, and the strongly expressed conviction that a true understanding of the quantum laws would necessitate a radical departure from the fundamental conceptions of classical physics. It was in this invigorating atmosphere that Kramers took the decisive step of treating the theory of optical dispersion from the point of view of correspondence. This was quite a natural step in the course of the research which was systematically progressing at Copenhagen; but at the time it could certainly not have been foreseen that it would lead so rapidly to such fundamental consequences.

At this juncture, the young Heisenberg arrived from Germany, and was quickly introduced to Bohr's ideas by working with Kramers at the further refinement of dispersion theory. He then perceived that the quantized amplitudes of atomic resonators could be regarded as a new kind of algebraic symbol, depending on the pairs of integers which characterize possible quantum transitions; and that the rules for handling these quantities, which the correspondence argument had suggested, could be condensed into a simple mathematical law of multiplication. In contrast with the simpler problems of emission and absorption, the phenomenon of dispersion was, in fact, the first case involving products of amplitudes pertaining to different transitions. Heisenberg thus discovered an algebraical symbolism which was the natural instrument for expressing the kinematical (as opposed to dynamical) relationships of quantized physical entities.

As to the precise nature of this algebra, Heisenberg himself was at first very much in the dark. But the announcement of his momentous discovery found a quick response. Born, familiar as he was with the theory of matrices developed in Hilbert's mathematical school at Göttingen, was struck by the resemblance of Heisenberg's multiplication rule with the corresponding rule for matrices. With the help of one of his most gifted pupils, Jordan, he soon recognized that this resemblance was, in fact, an identity, and he was able, for the first time, to put the kinematical relation between co-ordinate and momentum found by Heisenberg into the neater and considerably more general form well known to-day as the canonical commutation rule. The importance of Born's contribution was, above all, to place at the disposal of the physicists the formidable arsenal of matrix theory. With this refined weapon in hand, Born, Jordan and Heisenberg were able to produce at an incredible speed the famous paper in which the complete foundation of the new quantum mechanics was firmly laid.

Heisenberg's first paper, however, elicited another, highly original reaction from a Cambridge student, who at the time was one of the few engaged in the search for a rational quantum theory. The way in which Dirac developed his own extension of Heisenberg's fundamental idea, leading to an equivalent and independent foundation of quantum mechanics, bears the mark of his peculiar genius. Like Born and Jordan, he starts from the commutator between co-ordinate and momentum; but he is not fettered by any special representation of quantum algebra, such as the matrix calculus. He goes straight back to the correspondence argument and establishes a correspondence, in this sense, between the commutator and the Poisson bracket of classical mechanics. This gives him the key to the whole edifice. An epic grandeur

pervades this paper of Dirac's; one is reminded of Maxwell's translation of the electromagnetic field conception into mathematical symbols.

In discussing the interpretation of the matrix elements in terms of transitions between stationary states, Heisenberg had stressed the fact that the new formalism was strictly adapted to observable quantities, whereas auxiliary concepts like the orbits of classical mechanics were entirely eliminated. This bold innovation in the attitude towards mechanical models of atomic phenomena was undoubtedly a first step in the elaboration of a logically consistent system of concepts of quantum mechanics. But the sharp formulation given to it by Heisenberg had a weakness that could not long escape attention. It was above all Pauli, then in Copenhagen, who directed his critical acumen to this fundamental question. He presented the difficulty in a striking way by a picturesque illustration: the moon is, strictly speaking, in a stationary state; yet there is no doubt about its localization on its orbit. Heisenberg's philosophy of observables therefore shot beyond its mark; in fact, it obscured the correspondence with the classical theory, which ought to appear as a limiting case of the new mechanics. Obviously, a more general representation of the quantum algebra than that provided by matrix theory was needed in order to account for situations in which the localization of particles plays a prominent part.

Scarcely had this problem been clearly recognized among Bohr's disciples than its solution came unexpectedly from quarters quite unconnected with the trend of thought of the Copenhagen school. Struck by the dual nature of light, which manifests itself both as waves and particles, Louis de Broglie had, two years before, attempted to follow up the speculative extension of this duality to matter: he associated with a free particle a group of waves moving with the same velocity, and he even tried to interpret the quantum conditions defining the stationary states of a system of particles as conditions of stationariness of the associated waves. These bold suggestions were taken up with great determination by Schrödinger; he succeeded in giving them an acceptable form by an ingenious application of another product of the Göttingen school, the theory of eigenfunctions, which had just received a masterly exposition in Courant and Hilbert's famous textbook.

The reaction of the school of quantum mechanics to Schrödinger's work was immediate and decisive. Pauli saw at once that the formalism of wave mechanics was fundamentally equivalent to that of quantum mechanics (this had also been pointed out by Schrödinger himself), and provided the desired extension of the latter for dealing with the localization of particles. Born showed how the new method, in particular, was adapted to the treatment of collision processes; on this occasion, he formulated the precise rules for the interpretation of wave-functions, consonant with Bohr's views about the essentially statistical character of our description of atomic phenomena. Jordan and Dirac, independently, emphasized the role of the wave-function as a canonical transformation, and worked out a comprehensive presentation of the theory, based on this concept, which entirely elucidated the relationship between stationary states and spatial localization and the general statistical features of quantum processes.

The least pleased with this breath-taking development was probably Schrödinger himself. He had hoped that the introduction of wave conceptions would have reconciled the kind of discontinuity expressed by the quantum postulates with a spatio-temporal picture fundamentally similar to that of classical physics: in particular, his aim was to eliminate the statistical features connected with quantum transitions by means of a causal description involving wave interferences. "Had I known," he declared with his usual terseness, "that we should not get rid of this jumping about (*Herumspringerei*) of the electrons, I'd rather not have intervened in this business." To which Bohr pointedly retorted: "You may think so, but *we* are deeply grateful for your intervention". For Bohr and his disciples, in fact, there was never any doubt that the quantum postulates meant a radical break from the causal point of view of classical physics. They hailed Schrödinger's theory as the symbolism exactly suited to a consistent formulation of the entirely new kind of non-causal relationship occurring in atomic theory. Bohr's address at the Como Congress, in the autumn of 1927, fittingly concludes the phase of creation of quantum theory. In it, he gives a penetrating analysis of the uncertainty relations, set up shortly before by Heisenberg, and he introduces for the first time the idea of complementarity, which expresses the essentially new logical structure of the conceptual framework of quantum mechanics.

L. Rosenfeld

QUANTUM MECHANICS AND ASTROPHYSICS

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Since the aim of astrophysics is to study the whole physical universe, and since the concepts of quantum mechanics have permeated the whole of fundamental physical theory, it would be almost impossible completely to disentangle the influence of quantum mechanics on the recent development of astrophysics. No such task is attempted here. We survey only certain of the more direct applications of quantum mechanics to characteristically astrophysical situations. The interest of such a survey, in the first place, lies in the circumstance that cosmical physics naturally provides a much more extensive range of physical conditions in which to apply the theory than does laboratory physics. In the second place, the interest is to inquire whether further advances in atomic physics appear to be demanded by astrophysical considerations.

Certain general observations are needed. First, there is the remarkable fact that much of the progress in astrophysics that might appear to depend essentially upon the use of quantum mechanics was, in fact, achieved by exploiting to the utmost the potentialities of the 'old' quantum theory. It so happens that the work described in Eddington's "Internal Constitution of the Stars" (Cambridge, 1926) was completed on the eve of the discovery of the 'new' quantum theory and well illustrates this point. Incidentally, Eddington's book also serves admirably as an account of the position reached in general astrophysics at the beginning of the period now under review.

Second, the existence of quantum mechanics has not had a very obvious effect upon the sort of observa-

tional work carried out in astrophysics. The most that can be claimed is that it may have partly determined the emphasis laid upon certain types of work, especially on the determination of profiles of spectral lines (see below). Certainly no observations can be quoted as having been designed crucially to test any particular prediction of quantum mechanics. Attention may therefore be concentrated mainly upon theoretical developments.

For our purposes here, it is more profitable to think in terms of the chief new concepts that have guided recent advances in astrophysics, rather than of the advances themselves. One would venture specially to mention among such concepts those concerning: (*a*) states of matter; (*b*) formation of spectra; (*c*) nuclear reactions; (*d*) interstellar matter; (*e*) the apparent expansion of the universe. We notice briefly the significance of quantum mechanics for each of these.

States of Matter in Stellar and Planetary Bodies

R. H. Fowler's application[1] of the quantum mechanical theory of degeneracy and of zero-point energy to account in a general way for the observed characteristics of white-dwarf stars is the most clear-cut example of the solution of an astrophysical problem depending upon features in which quantum mechanics differs essentially from any previous theory. Moreover, astrophysics provides much the most extensive applications of the properties of degenerate matter (including recently, for example, its thermal conductivity[2]) which otherwise find practical illustration of only a restricted character in the theory of electrical and thermal conductivities of laboratory materials. Further, the theory of relativistic degeneracy as developed by E. C. Stoner[3] and W. Anderson[4] and S. Chandrasekhar[5], which is generally recognized as needed for a full investigation of the white-dwarf problem, may be claimed as the most direct application yet made of Dirac's relativistic form of the wave-equation.

W. H. Ramsey[6] has recently developed a highly promising theory of the constitution of the earth and the terrestrial planets on the basis of the phase-change to a metallic state produced in their material by pressure. This is a phenomenon characteristic of the quantum mechanical theory of the 'solid' state. More recently still[7], Ramsey has extended his theory to the constitution of the major planets, with apparently satisfactory results. He has shown, moreover, how his theory provides a smooth transition from the 'planetary' to the 'white-dwarf' state with increasing mass of the body concerned. It may therefore be regarded as in principle completing the quantum mechanical treatment of the problem of this transition, the solution of which was first tentatively sketched by H. N. Russell[8] and D. S. Kothari[9].

Formation of Spectra

Probably no single type of astrophysical observation has contributed so much in recent times to the accumulation of astrophysical knowledge as has the study of line-profiles (including, of course, the derivation of line-intensities) in astronomical spectra. This study, which is now being carried out in observatories all over the world, was started, using modern photometric methods, at Potsdam and at Utrecht in 1927, and so its development very nearly covers the period under survey. It yields a wealth of information about the physical state of the gas producing the spectral lines: its density, atomic motions and mass-motions, its state of excitation and ionization, its chemical composition, the number of its atoms producing a given line, and the radiational and electromagnetic field in which the gas is situated. This information is derived from the application of a highly developed theory of line-formation using all the resources of atomic theory, kinetic theory, and the theory of radiative transfer. It is not too much to say that the general theory of line profiles (though not necessarily in every particular application) employs almost all the most delicate developments of quantum mechanics, and has, in fact, itself stimulated many of these developments. A comprehensive review of the subject has been given by H. H. Plaskett[10], including references to the quantum-mechanical work involved.

In the general context of line-formation, one might be expected to mention the identification by I. S. Bowen[11] of the 'nebulium' lines as due to 'forbidden' transitions of oxygen, nitrogen and neon, and by B. Edlén[12] of the 'coronium' lines as due to 'forbidden' transitions of iron, nickel, calcium and argon atoms deprived of ten to fifteen electrons. The former did not, however, depend upon the use of quantum mechanics as such. The latter depended upon a variety of empirical and theoretical evidence which did include transition-probabilities depending upon essentially quantum-mechanical calculations.

A satisfactory explanation of the general opacity of the sun's atmosphere was reached only comparatively recently in terms of the negative hydrogen ion[13]. The existence of this system and its properties are purely theoretical predictions of quantum mechanics. It has not been possible to verify these by laboratory observations. Conditions in the solar photosphere are, however, precisely those which the theory demands for the operation of the predicted effects, and the calculated results accord well with the observed characteristics of the sun's continuous spectrum.

Nuclear Reactions in Stars

The most fundamental advance in astrophysics during the period concerned has been the establishment, almost beyond doubt, of the fact that the predominant process of energy-generation in stars is the conversion of hydrogen into helium. The most important set of thermonuclear reactions involved are probably those of the 'carbon–nitrogen' cycle[14]. This advance has depended primarily upon experimental progress in nuclear physics. When the experimental results are used in deriving the formulæ required in the astrophysical applications, an essential step is, however, the appeal to a standard quantum-mechanical calculation for the probability of a proton of given energy penetrating a given atomic nucleus. Were the quantum mechanics of nuclear processes more advanced than it is at present, it would presumably lead to a more completely theoretical treatment of the subject of energy-generation than is now possible.

Interstellar Matter

The interpretation of the observed distribution and motion of the stars in the galaxy, the study of the relation of a star to its cosmic environment, and the theory of the evolution of the whole galactic system

are at the present time dominated by the study of interstellar matter[16]. This is a development in astrophysics which has occurred mainly within about the past ten years. The total amount of the matter is probably about the same as that condensed into stars. It consists mainly of hydrogen, with a presumably small percentage of helium, and something of the order of one atom in 50,000 of heavier elements. It is mostly in the form of gas, including a small admixture of molecular combinations (CH, NH), but about one per cent is in the form of interstellar 'dust'. The density in a typical region is of the order of one atom per cubic centimetre.

Since the condition of the material is far removed from thermodynamic equilibrium, its state can be studied only by an exhaustive consideration of all the atomic processes of excitation, ionization, condensation, etc., taking place. Most of these processes at some stage require quantum mechanical considerations. Without going into more detail, it can therefore be seen that quantum mechanics is intimately involved in this great new development of astrophysics.

The Expanding Universe

There is no generally accepted relation between quantum mechanics and the concept of the expanding universe: further mention of this is deferred to the concluding section.

General Significance

In the above brief summary it has not been possible to discuss the quantitative comparison of theoretical with observational results. Broadly speaking, it may be claimed that, wherever the comparison may legitimately be regarded as providing a test of the predictions of quantum mechanics, the agreement is found to be satisfactory having regard to the uncertainties in the astrophysical observations and the numerical approximations in the theoretical work.

Astrophysical research does not appear to have revealed any limitations in quantum mechanics beyond those encountered in the development of the theory itself or those known to laboratory physics. But, in spite of the fact that astrophysics provides a much wider range of application than does laboratory physics, it is only fair to recognize that in most of this extended range it does not yet provide very stringent numerical tests. In the most characteristic astrophysical applications the position is rather that without quantum mechanics it is impossible to come within sight of a solution, than that the quantitative results of the quantum-mechanical calculations can yet be claimed to be verified within even a few per cent.

The Future

It may first be asked how expected developments in atomic theory are likely to influence astrophysics. The greatest developments in the near future are expected to be in nuclear physics. If a new 'quantum mechanics' of the atomic nucleus does emerge, it is bound to influence all parts of astrophysics concerned with nuclear processes—those proceeding in normal stars and those in supernovæ and other 'abnormal' stars. In this way it may be expected to yield a greatly improved understanding of the observed relative abundances of the chemical elements and thence to yield new knowledge about the evolution of the universe.

In the present setting it is, however, more pertinent to ask whether further developments in theoretical atomic physics appear to be indicated or required specifically by problems in astrophysics. There are, of course, many unsolved problems in astrophysics the formulation of which carries no implication whatever that existing general physical theory will prove inadequate for their solution. On the other hand, the problems of the origin of cosmic rays, the origin of stellar and other magnetic fields, the polarization of light in its passage through interstellar space, and the nature of the recently discovered 'radio-stars', are ones that may conceivably have to await fresh developments in atomic physics for their solution. However, none of these problems is yet in the position that, for example, the white-dwarf problem was in twenty-five years ago, when Eddington had shown how the application of then existing theory actually led to a paradox.

In a most fundamental regard, astrophysics does, however, point the way to a great development in general physics. For it is impossible to avoid the conviction that the parameters of the whole observable universe, its size, its mass, and Hubble's constant for the recession of the galaxies, must be related to the fundamental constants of atomic physics. The discovery of the relations was the aim of Eddington's later work, though his particular ideas have gained little acceptance. A more promising approach may be through the concept of continuous creation in the form recently proposed by Bondi and Gold[18] and by Hoyle[17]. For in their view the parameters of the universe are determined by the creation-rate, which is itself an 'atomic' parameter. If the relations are established, in this or any other way, they must presumably show why the galaxies have the ages, sizes, and so on, which are inferred from observation, and thence, in turn, why the stars have their observed masses, etc.—in short, why the universe is what it is observed to be—all in terms of an extended quantum mechanics. The underlying problem is the well-known one of the unification of quantum theory and relativity theory. Astrophysics certainly supplies the phenomena for which an adequate solution must account and has possibly already, through the hypothesis of continuous creation, brought the solution one stage nearer achievement.

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QUANTUM MECHANICS AND LOW-TEMPERATURE RESEARCH

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AND
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LOW-TEMPERATURE physics is to-day an important and flourishing part of physics. Fifty years ago, before the advent of the quantum theory, this was not so. In the classical picture we have the law of equipartition of energy, according to which "degrees of freedom are counted only, and not weighted". This means, for example, that the specific heat of a solid is constant down to absolute zero, which in turn implies that between any finite temperature and absolute zero all entropy differences are infinite.

This fact has two consequences: it is impossible to attain absolute zero; and we cannot extrapolate entropy data to absolute zero. This point is therefore of no particular thermodynamic interest, and certainly cannot be used as a reference point for equilibrium calculations. Experimental workers in the pre-quantum times do not seem to have expected much more than to find repeated with one substance of lower boiling point what was already known with other substances of higher boiling point, and similarly not to have expected to find any striking new phenomena in the electrical and magnetic behaviour of materials. This is perhaps expressed a bit too crudely, for in every experiment there is the element of curiosity and the hope of the unexpected, best exemplified perhaps by the work of Dewar and Kamerlingh Onnes; but, as a whole, low-temperature research had no wide appeal.

All this was changed with the development of the quantum theory and the discovery and interpretation of low-temperature quantum effects. Most decisive, perhaps, was Einstein's explanation of the falling off of specific heats and the prediction that they would approach zero at zero temperature. Entropy differences now become finite between absolute zero and finite temperatures, and absolute zero becomes a thermodynamic reference point of the highest importance. At about the same time, this had been expressed in the enunciation of Nernst's Theorem, derived intuitively from considerations concerning chemical equilibria at ordinary or high temperatures. It finally led to the statement that entropy differences between all states of a system, which are in internal equilibrium, disappear at absolute zero. In a somewhat abbreviated way one can say that substances in a state of thermodynamic equilibrium at absolute zero are in a state of perfect order—a state of affairs only possible in a quantum world. This, the Third Law of Thermodynamics, is to-day the most important guiding principle in low-temperature research. It is true that this Law also entails the unattainability of absolute zero, but in a different sense. It no longer constitutes an obstacle to our knowledge, for we can now extrapolate properties to absolute zero.

Quantum effects are thus the dominating interest in low-temperature research. One of the most important is zero-point energy. In the second form of the quantum theory, Planck assumed that the energy of a vibrator in the lowest state was not zero but $\frac{1}{2}h\nu$, which led to exactly the classical energy at high temperatures. Lindemann first showed that there must be a difference in the behaviour of the vapour pressure of isotopes with or without zero-point energy. The indications at the time supported it, but they were not conclusive. Further indications of the zero-point energy were given by the study of the melting point and of the law of corresponding states. The first quantitative proof came from the study of X-ray diffraction intensities at low temperatures. Later the study of the spectra of diatomic molecules confirmed this. Finally, the new quantum mechanics showed the necessity of zero-point energy, and to-day many exact proofs exist for it.

The most striking example is perhaps liquid helium. Here the small atomic mass of helium, leading to strong quantum effects, combined with weak interatomic forces, giving a very small lattice energy, result in a zero-point energy of the same order as the lattice energy. Consequently helium cannot solidify and is thus prevented from reaching the state of perfect order in the normal way. Instead, it passes into a state of liquid degeneracy (helium II), with all the remarkable effects on which much of the interest in low-temperature physics is now concentrated.

Gas degeneracy, another quantum phenomenon exhibited at low temperatures, depends for its explanation on a deeper aspect of quantum mechanics—the symmetry of wave functions, which expresses the indistinguishability of identical systems, such as molecules. Application of this symmetry principle to hydrogen gives the explanation of the behaviour of ortho- and para-hydrogen as two virtually separate components of hydrogen, with different specific heats. Gas degeneracy takes two forms, characterized by the Bose–Einstein and the Fermi–Dirac statistics, corresponding to symmetry or antisymmetry of wave functions with respect to the interchange of identical systems. It has been conjectured, with some plausibility, that the unique behaviour of helium II is due to a similar 'liquid degeneracy'. This question is of considerable interest at the present moment, for the very rare isotope of mass 3, of which small quantities are now becoming available for experiment, obeys the Fermi–Dirac statistics, while the normal isotope of mass 4 obeys the Bose–Einstein statistics. Interesting differences in behaviour are expected, and some are already found.

Electrons, being very light, exhibit degeneracy to an extreme degree, even at high temperatures when their density is high, as it is in metals. This explains their very small contribution to the specific heat of metals, which only becomes noticeable at very low temperatures, when the lattice specific heat becomes even smaller. The variation of electrical and thermal conductivities with temperature is satisfactorily explained only in terms of ideas which are definitely quantal. The phenomenon of superconductivity still remains without an accepted explanation, however, although it is clear that it also is an essentially quantal phenomenon.

The magnetic behaviour of materials at very low temperatures is of particular importance for low-temperature physics, for the lowest temperatures are attained by magnetic methods. Here again, quantum mechanics has played a determining part in the understanding of the phenomena. Bohr's old quantum theory gave a general explanation of paramagnetism and diamagnetism in terms of the quantization of angular momentum. But the new quantum mechanics, with its unambiguous rules for dealing with the angular momentum of complex atoms and the

magnetic effect of the spin of the electron, is necessary to give a quantitative theory adequate for low-temperature research. Future developments, in the way of even lower temperatures, involve an even greater reliance on quantum mechanics as a guide to the interaction between the magnetism of nuclei and the thermal motion of the lattice, through which the attainment of these very low temperatures is to be effected.

It will be seen from this very brief survey that modern low-temperature research derives its chief interest from the impetus of the quantum theory. It is difficult to separate the old and the new quantum theory in this development. The old theory was adequate for the theory of the specific heats of solids, and up to a point for the understanding of gas degeneracy and magnetism; the new theory is required for a quantitative explanation. Ortho- and para-hydrogen, on the other hand, could scarcely have been intelligible in terms of the old theory. In the theory of metals, the specific heat could have been understood on the old theory, supplemented by Pauli's principle (actually contemporaneous with the birth of the new quantum mechanics, but independent of it); but conductivity can only be fully understood in terms of the new. Quantum mechanics, in its modern form, is certainly necessary for the understanding of those phenomena connected with extreme degeneracy, in which macroscopic systems exhibit quantal features usually only found in the atomic domain, such as superconductivity and helium II. Much has been learnt in twenty-five years; but the subject is not closed, and there are still many promising lines of research to follow, though it would perhaps be too optimistic to hope that any revolutionary development of physical theory will come from low-temperature research.

OBITUARY

Sir Sidney Harmer, K.B.E., F.R.S.

THE death of Sir Sidney Frederick Harmer on October 22 after long years of disability removed the last survivor of a remarkable group of naturalists on the staff of the University of Cambridge in the closing decades of the past century: Alfred Newton, Adam Sedgwick, Bateson, Gadow, Harmer, Hickson, Sharp—all of them fellows of the Royal Society—each one of them, by original research, teaching and personal influence, playing an important part in the advancement of zoological science.

Born in Norwich in 1862 with a heritage of ability which had found expression in his father's rise to high position in business and in public affairs, Harmer had the further advantage of a childhood spent in an atmosphere of interest in science, his father being an enthusiastic student of the palæontology of East Anglia. His formal training in zoology was initiated at University College, London, and carried forward at Cambridge, where in due course he obtained first-class honours in the Natural Sciences Tripos, Parts 1 and 2, a University lectureship in zoology, and a fellowship of his College (King's). In 1891 he succeeded J. W. Clark as superintendent of the University Museum of Zoology.

As a University teacher, Harmer's duties were concerned with the advanced training of students who had already obtained honours in Part 1 of the Tripos. His teaching was admirably designed to give a balanced and judicial summary of existing knowledge of the particular section of the animal kingdom with which he was dealing, while at the same time inculcating these ideals to be aimed at in all scientific work—industry, patience and accuracy in observation, clarity and precision in record, and abhorrence of hurried clutching at results. Harmer's capacity as a teacher is well brought out by his section, "Polyzoa", in the "Cambridge Natural History", of which great work he acted as joint editor with Shipley. His admirable articles in the "Encyclopædia Britannica"—more especially those on Polyzoa and Cetacea—provide further testimony to this capacity.

In the field of original research, Harmer's Cambridge activities were specially concentrated upon the Polyzoa; he adhered loyally to J. V. Thompson's name for the group in spite of the more general use of Ehrenberg's "Bryozoa". His long series of memoirs on the classification, morphology, physiology and distribution of the Polyzoa brought him world-wide recognition as perhaps the leading authority on the group. Almost at the beginning of the series is his remarkable work on *Pedicellina*, while its culmination is found in his report upon the Polyzoa of the *Siboga* Expedition, which he regarded as the most important of all his works.

An important side-issue of Harmer's work on the Polyzoa was his investigation of a remarkable little animal, *Cephalodiscus*, first obtained by the *Challenger* Expedition. At first regarded as a compound Ascidian, it was later thought to be a polyzoon, and as such came under the notice of Harmer, who as a result of detailed investigation demonstrated the surprising fact that *Cephalodiscus* was no polyzoon but rather an ally of *Balanoglossus*, and therefore of the Chordata.

During Harmer's later years in Cambridge, his teaching and research activities were encroached upon by the administrative work falling to the superintendent of the Museum of Zoology. In this post he was a great success, combining the acquisitive instincts proper to the museum curator with the greatest care in classifying and cataloguing, and the scrupulous conscience which regarded gifts to the Museum as sacred even when they no longer roused particular topical interest.

Harmer's reputation as superintendent of the University Museum of Zoology led to his appointment in 1907 as keeper of zoology in the British Museum (Natural History), this in turn leading up to his appointment in 1919 as director of the Natural History Museum. His appointment followed the publication in *The Times* of March 1 of that year of a letter signed by twenty-two leading men of science, with a relevant leading article, inspired by leakage of a recommendation by the general body of British Museum trustees to the three principal trustees (the electoral body) that they should appoint as director a layman, the very efficient assistant secretary.

The directorship of the Natural History Museum, involving the official leadership of British naturalists, meant inevitably the broadening out of Harmer's activities over an area which cannot be adequately covered in the space here available. Outstanding among them must be mentioned his vice-chairmanship of the "Discovery" Committee, one result of which was to revive and intensify his old interest in the Cetacea. An important outcome of this was his organizing machinery for reporting, through the

coastguards and receivers of wrecks, all strandings of whales noted around the coasts of Britain. This led to a great increase in the amount of material available for study by specialists on the Cetacea, and as a result to important advances in knowledge. Mention must also be made of Harmer's long and active interest in the Marine Biological Association and the work of the Plymouth laboratory.

On retiring from the directorship of the Museum in 1927, Harmer was able to concentrate upon his *Siboga* Report, of which Parts 1 and 2 had appeared in 1915 and 1926. Parts 3 and 4 were duly completed, but the text and illustrations of Part 4 unfortunately reached Holland just before the German occupation of that country, and their supposed loss was a blow from which Harmer never really recovered. When eventually news came of their safety, it was too late to bring relief. Happily they are now in the capable hands of Dr. Anna Hastings, and the publication of this concluding part of Harmer's great work should not be long delayed.

Harmer's last years were spent at Melbourn and then at Cambridge, where he died. He is survived by his wife, Laura, daughter of A. P. Howell, and by their son and daughter.

His scientific work received wide recognition. He was knighted in 1920. Elected a fellow of the Royal Society in 1898, he served on the Council and was vice-president during 1922–24. Fellow of University College, London; honorary fellow of King's College, Cambridge; president of the Linnean Society of London; foreign member of the Norwegian and Swedish Academies; honorary member of the Boston Society of Natural History and the Société Zoologique de France; gold medal of the Linnean Society of London; these were among his long list of distinctions.

JOHN GRAHAM KERR

NEWS and VIEWS

Nobel Prize for Chemistry for 1950: Prof. O. Diels and Prof. K. Alder

THE Nobel Prize for Chemistry for 1950 has been awarded jointly to Prof. Otto Diels and his former pupil, Prof. Kurt Alder, for their work on the diene synthesis. This award will be acclaimed by organic chemists generally as a fitting acknowledgment of one of the outstanding achievements of organic chemistry. The names of Diels and Alder will be inseparably linked in the annals of chemistry, and their combined names with the diene synthesis which they developed. Prof. Diels, who will shortly celebrate his seventy-fifth birthday, has been professor of chemistry at the University of Kiel since 1916. Prof. Alder now occupies the chair of chemistry and chemical technology in the University of Cologne. Their first paper on the reaction of dienes with quinones was published in 1928. Similar additions had already been recorded by other workers, and in particular by von Euler and Josephson, who in 1920 described the reaction of isoprene with benzoquinone and correctly formulated the product. It was Diels and Alder, however, who provided the first experimental proof of the nature of the reaction and who appreciated and demonstrated its wide application to the synthesis of ring compounds of many types. The ease with which the diene synthesis occurs, without the need for powerful chemical reagents, is one of its most remarkable features, and study of the reaction has also contributed greatly to knowledge of polymerization processes by which plastic materials of great practical value have been obtained. It is probable that many plant products are formed in Nature by diene additions. Prof. Alder, who is still actively working on the diene synthesis, has made important contributions to the stereochemistry and the energetics of the process. Prof. Diels is also noted for his work on other aspects of organic chemistry, and in particular for his studies on cholesterol, which culminated in his discovery of the method of dehydrogenation with selenium.

Royal Society: Medal Awards for 1950

H.M. THE KING has been graciously pleased to approve recommendations made by the Council of the Royal Society for the award of the two Royal Medals for 1950 as follows: Sir Edward Appleton, for his work on the transmission of electromagnetic waves round the earth and for his investigations of the ionic state of the upper atmosphere; Dr. C. F. A. Pantin, for his contributions to the comparative physiology of the Invertebrata, particularly his work on nerve conduction in Crustacea and Actinozoa.

The following awards of Medals have been made by the President and the Council of the Royal Society: Copley Medal to Sir James Chadwick, for his outstanding work in nuclear physics and in the development of atomic energy, especially for his discovery of the neutron; Rumford Medal to Air Commodore Sir Frank Whittle, for his pioneering contributions to the jet propulsion of aircraft; Davy Medal to Sir John Simonsen, for his distinguished researches on the constitution of natural products, especially the plant hydrocarbons and their derivatives; Darwin Medal to Prof. F. E. Fritsch, for his distinguished contributions to the study of algology; Hughes Medal to Prof. M. Born, for his contributions to theoretical physics in general and to the development of quantum mechanics in particular.

Royal Observatory, Cape of Good Hope: Dr. J. Jackson, F.R.S.

DR. JOHN JACKSON has recently retired from the post of H.M. Astronomer and Director of the Royal Observatory, Cape of Good Hope. Dr. Jackson was appointed chief assistant at the Royal Observatory, Greenwich, in 1914. He edited the double-star observations made at Greenwich, which he used together with observations elsewhere for the investigation of the orbits of many binaries and for the determination of dynamical parallaxes. In conjunction with Mr. Bowyer he made a study of the performance of the Shortt free-pendulum clocks; the effect of the short-period nutation terms was shown, and it became necessary to introduce the conception of mean or uniform sidereal time. The reduction, jointly with Dr. H. Knox-Shaw, of the observations made by Hornsby at the Radcliffe Observatory, Oxford, in the years 1774–98 was an important contribution to fundamental astronomy. In 1933 Dr. Jackson was appointed H.M. Astronomer at the Cape, and has fully maintained the high traditions of that important southern Observatory. The stellar parallax programme and the photographic determinations of star places were vigorously continued.

The analysis of the proper-motions of 20,843 stars, derived from the Cape astrographic plates, was of special importance to stellar statistics, because of their wide range in galactic latitude. Under his directorship the Cape Observatory has undertaken an extensive programme of stellar photometry, providing for the first time photographic and photovisual magnitudes of high accuracy of many stars in the southern sky. Dr. Jackson has been president of the Commission on Meridian Astronomy of the International Astronomical Union, and is now president of the Commission on Stellar Parallaxes and Proper Motions.

Dr. R. H. Stoy

Dr. R. H. Stoy, who succeeds Dr. Jackson and so becomes the ninth H.M. Astronomer at the Cape, has been chief assistant at the Royal Observatory, Cape of Good Hope, since 1935. Born at Wolverhampton and educated at King Edward VII School, Birmingham, he went to Gonville and Caius College, Cambridge, to continue his mathematical studies. From an early age he had been interested in astronomy and he continued to work on this subject. After taking his degree, he was awarded a Commonwealth Fellowship and went to the Lick Observatory, where he spent the years 1933–35. He investigated problems connected with the spectra of nebulæ, for which work he was awarded a Ph.D. degree at Cambridge. His interest in practical astronomy made him an ideal astronomer for the Cape Observatory, where he went on returning from the United States. At the Cape he found that a large programme of work had been started to determine the positions and magnitudes of stars down to the ninth magnitude south of dec. − 30°. For the positional work the necessary framework was already available, and it was hoped to determine the brightness of the stars by means of standards at declination − 45°. Dr. Stoy soon found that the standards available were not sufficiently accurate, and a great deal of his time during the past ten years has been concerned with the setting up of accurate standards at declination − 45° for both photographic and visual magnitudes, and connecting them with the best standards in the sky north of the equator visible from South Africa. In this work he collaborated with Prof. R. O. Redman, now director of the Cambridge Observatories, but working at the Radcliffe Observatory, Pretoria, until 1947.

Voyage of the Royal Research Ship *William Scoresby*, 1950

The Royal Research Ship *William Scoresby* recently arrived in Plymouth after a ten-month voyage of research on oceanography and whales in South African waters. This veteran research ship was built twenty-four years ago for the Discovery Committee and is equipped for general oceanographical work, trawling and marking of whales. The voyage has been a continuation of the Discovery Investigations, and the whole work is controlled by the National Institute of Oceanography (see *Nature*, January 21, p. 105). The principal items of research during the voyage were surveys of the Benguela Current off South-West Africa at two different times of year, and whale marking and a short survey of the Agulhas Current in south-east African waters. The investigations of the Benguela Current included a series of observations on the physical, chemical and biological features of the waters, carried out during the first part of the voyage and then repeated during September–October. In this region, cold water wells up from the ocean depths, bringing nutrient salts to the surface and thereby stimulating the growth of marine life. But, in spite of the rich marine life, the sea floor in this locality is remarkable for a considerable area of sterile mud containing hydrogen sulphide, and the researches of the expedition should add considerably to present knowledge of the extent of the sterile region. It has been suggested that the deposit of organic debris which takes place in such 'azoic' muds is connected with the formation of oil deposits. The whales marked in the south-east African region and at various other points in the voyage included a high proportion of sperm whales, a species the habits of which are little known, and this part of the work is the first occasion on which any substantial numbers of whales have been marked in tropical and subtropical waters. During most of the voyage, Mr. R. Clarke was in charge of the scientific work, assisted by Mr. R. I. Currie.

Modern Developments in Radio Engineering

In his presidential address to the British Institution of Radio Engineers on September 27, Mr. P. Adorian pointed out that during the coming year the Institution will be celebrating its twenty-fifth anniversary and that plans are being made to hold a convention to cover many fields of radio engineering. He then gave a brief survey of achievements in recent years in radio engineering with an indication of possible future developments, particularly in matters concerning industrial electronics, aeronautics and broadcasting. Mr. Adorian emphasized that, while radio engineers seem to appreciate that numerous production and operation methods could be made more efficient by the use of electronic techniques, it is surprising to find how little of this knowledge is applied in practice in industry and in medical science. In the field of aeronautics, while modern air transport would be impossible without radio communication and navigational aids, there seems to be a need for speeding up and simplifying signalling methods to keep pace with the steadily increasing speed of modern aircraft.

After reviewing the progress of broadcasting towards the ideal of providing a satisfactory service in all populated areas of the world, Mr. Adorian referred briefly to a relatively new method of using short-wave radio for the provision of a local service. Basically, the system consists of high-frequency transmitters with aerials which radiate mainly in a vertical direction, giving relatively short-range reflexions from the ionosphere. The first of these systems began operating in India several years ago; in 1947 Radio Trinidad started to broadcast on this principle on a wave-length of 30 m. (10 Mc./s.), while last July a station of the same type was installed in Jamaica, using a wave-length of 60 m. (5 Mc./s.). Local reception is satisfactory during daylight; but at night interference is experienced with the transmissions from distant high-power stations operating on the same frequencies.

Biology and Control of Pharaoh's Ant

The most familiar ant in houses in Great Britain is the common black ant *Lasius niger*, but a much more serious pest when it occurs is the tiny insect known as Pharaoh's ant, *Monomorium pharaonis* (L.), which measures less than three millimetres in length. A monograph by Prof. A. D. Peacock and others, recently published by the Department of Agriculture for Scotland (Misc. Pub. No. 17; pp.

51; Edinburgh and London: H.M. Stationery Office, 1950; 1s.), gives a detailed account of the biology and control of this insect. The authors attach more importance to poison baits than to contact insecticides as a means of control. Pieces of liver are smeared at suitable points, with the object of locating the nests and establishing regular trails. This is termed 'pre-baiting'. The poison bait, consisting of thallium sulphate and sodium fluoride mixed with syrup and liver or minced meat, or of sodium silico-fluoride and dried liver, is securely enclosed in tins suitably perforated to allow access by the ants and placed in the line of the established trails. The poison bait must be renewed once a week, and it is usually necessary to continue the process for six months or more before the entire brood in the nests has been effectively poisoned. Needless to say, these measures will be successful only if they are combined with a campaign for general hygiene and cleanliness.

Anniversary of Elliott Brothers, Instrument Makers

As a part of the celebrations this year of its 150th anniversary, the firm of Elliott Brothers (London), Ltd., is compiling a record of its activities and would like to hear of the whereabouts of Elliott instruments made during the nineteenth century. The firm originally made drawing and surveying instruments and acquired the business of Watkins and Hill about the middle of the past century. The available catalogues show that the products included many types of optical apparatus, as well as electrical apparatus which was supplied to the early experimenters. The company developed a calculating machine known as the arithmometer and, towards the end of the century, supplied a wide range of electrical indicating and recording instruments and telegraphic apparatus. Unfortunately, many specimens of this old apparatus and interesting photographs were destroyed during the Second World War, and the company would welcome any information about their early products. Correspondence should be addressed to Mr. A. H. Attwood, Elliott Brothers (London), Ltd., Century Works, Lewisham, S.E.13.

University of Glasgow

For the new session this year 250 new admissions have been made to the Science Faculty of the University of Glasgow. Altogether the University now has 6,645 matriculated students (5,298 men, 1,347 women), which is about 350 fewer than a year ago. In the Department of Chemistry, N. Grassie and V. Vand have been appointed Imperial Chemical Industries, Ltd., fellows. Dr. Grassie, a graduate of Aberdeen, will continue his study of the kinetics of high-polymer reactions which he started at the University of Birmingham. Dr. Vand graduated in physics and mathematics at the Charles University, Prague, and goes to Glasgow from Lever Brothers and Unilever, Ltd.; his work is in the field of X-ray crystal analysis and has special reference to mechanical methods of computation. Dr. R. P. Korf, a mycologist from the Department of Plant Pathology, Cornell University, with a particular interest in the taxonomy of the Discomycetes, is at the Botany Department of the University for a year on an exchange with Dr. S. A. Hutchinson. The librarian and keeper of the Hunterian Books and MSS., Dr. W. R. Cunningham, has resigned as from March 31, 1951.

Institution of Civil Engineers: Awards

The Institution of Civil Engineers has announced the following awards for papers read at meetings or published in the *Journal* during the session 1949–50. *Telford Premiums:* R. G. Braithwaite and D. J. Davies, jointly, for their paper on "Welded Highway Bridges"; and G. M. Binnie for his paper on "Some Notes on the Karun River and the Shatt-el-Arab". *Telford Premiums* for papers read at meetings of the following Engineering Divisions: *Railway Engineering Division*, A. H. Toms and W. F. Beatty; *Structural and Building Engineering Division*, W. S. A. Atkins; *Works Construction Division*, D. Lumbard and A. A. Wright; *Maritime and Waterways Engineering Division*, R. A. Stephenson; *Airport Engineering Division*, F. S. Snow. *Coopers Hill War Memorial Prize* to Dr. A. S. Thom for his paper on "Investigation of Tidal Phenomena in the Clyde Estuary, using a Scale Model". *Indian Premium* to Rai Bahadur B. B. Gupta for his paper on "Some Causeways on Sand Foundations across Rivers in India and their Development to Submersible Bridges". *Miller Prizes* for papers by students of the Institution to: A. Moores, P. Heatly, C. B. Wilby, J. A. G. Clarke, J. R. Willetts, R. J. Anderson, D. J. D. Wood, D. J. Skinner and H. E. Elliott. *Institution Medal and Premium* for a paper by an undergraduate of the University of London to J. R. Taylor.

Institute of Navigation

The following have been appointed officers for 1950–51 of the Institute of Navigation: *President*, Sir Robert Watson-Watt; *Vice-Presidents*, Air-Commodore C. E. Chilton and Captain G. C. Saul; *Honorary Treasurer*, F. G. G. Carr; *Chairman of the Technical Committee*, R. F. Hansford; *Chairman of the Executive Committee*, L. P. Kirwan; *Other Members of the Council*, Dr. E. Adams, E. L. T. Barton, Air Chief Marshal Sir Frederick Bowhill, Francis Chichester, Commander C. E. N. Frankcom, A. H. Jessell, Commander W. E. May, D. H. Sadler, Sir Harold Spencer Jones, Captain G. W. Wakeford and Captain F. J. Wylie.

Rear-Admiral Gordon McLintock, U.S.M.S., and Admiral of the Fleet Sir Henry Oliver have been made honorary fellows of the Institute.

International Congresses during 1951

In 1951 the following meetings associated with international scientific unions which are members of the International Council of Scientific Unions will take place. *Astronomy:* The Eighth General Assembly of the International Astronomical Union will be held in Leningrad and Pulkovo during August 1–8. *Chemistry:* The Sixteenth Conference of the International Union of Pure and Applied Chemistry commences in New York during September 8–9 after the meetings of the American Chemical Society (September 3–7), and will be concluded in Washington, D.C., during September 14–15, on which dates the National Bureau of Standards in Washington will be celebrating its fiftieth anniversary. The Twelfth International Congress of Pure and Applied Chemistry will be held in New York during September 10–13. *Crystallography:* The Second General Assembly and Congress of the International Union of Crystallography will be held in Stockholm during June 27–July 3. Following this there will be two symposia, on advanced techniques in structure determination and on electron

diffraction in liquids and gases respectively. Enrolment and offers of papers for these meetings should be made before February 15. *Geodesy and Geophysics:* The Ninth General Assembly of the International Union of Geodesy and Geophysics will take place in Brussels during August 21–September 1. The Assembly will be concerned with geodesy, hydrology, meteorology, physical oceanography, seismology, terrestrial magnetism and electricity and vulcanology. The Royal Society, through its British national committees, is the adhering body for Great Britain to each of the Unions, and available information on these Congresses can be obtained from the assistant secretary of the Royal Society, Burlington House, Piccadilly, London, W.1.

Christmas Lectures

A SERIES of three Christmas lectures, specially adapted for a juvenile audience of from twelve to seventeen years of age, will be held in the Royal Photographic Society's House, 16 Princes Gate, London, S.W.7, at 3 p.m. on December 28 and 29, 1950, and January 1, 1951. The lecturers and subjects will be as follows: "Slow-Motion Photography", by Mr. E. W. H. Selwyn; "How a Colour Photograph is Made", by Mr. L. W. Oliver; and "How to Photograph Buildings", by Miss Margaret F. Harker. Admission will be free but by ticket only, obtainable on application to the Secretary of the Society at the above address.

A series of three Christmas lectures on "Railways: How They are Built and How They Run", for boys primarily between thirteen and seventeen years of age, will be given at the Institution of Civil Engineers, Great George Street, London, S.W.1, at 3 p.m. on December 29, 1950, and January 1 and 3, 1951. These lectures are a repetition of the ones given four years ago, and the speakers will be Mr. Cecil J. Allen, Mr. L. G. B. Rock and Mr. O. S. Nock. Admission will be free but by ticket only, obtainable from the secretary of the Institution at the above address.

The Night Sky in December

NEW moon occurs on Dec. 9d. 09h. 28m., U.T., and full moon on Dec. 24d. 10d. 23m. The following conjunctions with the moon take place: Dec. 4d. 08h., Saturn 3° N.; Dec. 10d. 18h., Mercury 3° N.; Dec. 12d. 01h., Mars 3° N.; Dec. 14d. 13h., Jupiter 0·9° N.; Dec. 31d. 18h., Saturn 4° N. In addition to these conjunctions with the moon, Mercury is in conjunction with Venus on Dec. 27d. 21h., Mercury being 2·2° N. Mercury is an evening star, setting thirty-five minutes after the sun on December 1 and an hour and three-quarters after sunset on December 15, but towards the end of the month it draws too close to the sun for favourable observation. Venus is an evening star but is too close to the sun during most of the month for favourable observation; on December 31 the planet sets at 16h. 45m. and can be seen for a short time in the western sky, stellar magnitude −3·4 and practically all the illuminated disk being visible. Mars is an evening star and sets about 18h. 40m. throughout the month. Jupiter is an evening star, setting at 22h. 25m., 21h. 40m. and 20h. 55m. on December 1, 15 and 31 respectively. Saturn, a morning star, rises at 1h. 20m. on December 1 and at 23h. 30m. on December 31. Only one occultation of a star brighter than magnitude 6 occurs during the month, namely, 27 Taur. *m*, which disappears at 15h. 52·9m. as observed at Greenwich. The Geminid meteors are active during the first week of December; the radiant is close to θ Geminorum. Winter solstice is on Dec. 22d. 10h.

Announcements

THE French Ministry of Education has conferred on Miss E. Simpson, assistant secretary of the Society for Visiting Scientists, the honorary rank of Officier d'Académie in recognition of the work which she has done at the Society in the field of Anglo–French scientific co-operation.

MR. P. H. T. HARTLEY, of the Department of Zoological Field Studies, University of Oxford, has been appointed by the Council for the Promotion of Field Studies to be warden of Flatford Mill Field Centre in succession to Dr. E. A. R. Ennion.

DR. JOHN W. TAYLOR has been appointed deputy director-general of the United Nations Educational and Cultural Organization (Unesco) and will take up his duties in Paris on January 1. Dr. Taylor was born in Kentucky in 1905 and has been president of Louisville University since 1947. He was responsible for establishing in Louisville the first U.S. radio station for broadcasting educational and cultural programmes to the general public and to schools.

DR. W. H. Glanville, director of the Road Research Laboratory (Department of Scientific and Industrial Research) has been elected president of the Institution of Civil Engineers for 1950–51. The following officers have also been elected: S. J. L. Egerton (*treasurer*) and E. Graham Clark (*secretary*).

THE Rockefeller Foundation has made available to the University of Cambridge up to 7,000 dollars for the purchase of research equipment and supplies for the Department of Chemistry and up to 5,000 dollars towards the purchase of equipment for research in X-ray crystallography at the Cavendish Laboratory.

THE Pharmaceutical Society has received the sum of £1,000 on trust to establish a Humphreys Jones Scholarship in commemoration of the centenary year of the Liverpool School of Pharmacy and Mr. Humphreys Jones's association with the School for more than forty years.

THE Commonwealth Fund is offering three new fellowships open to British professional journalists with university or similar qualifications for a stay of about one year in the United States, commencing in September 1951, with the object of studying the factors affecting public opinion and general conditions in the United States. The fellowships are restricted to journalists of 25–35 years of age, who must be nominated by a responsible newspaper or journal. Applications must be sent in before January 1, 1951, to the Warden of Harkness House, 35 Portman Square, London, W.1.

A VERY limited number of the complete series of "Excursion Guides" of the Seventh International Botanical Congress (for the complete series of twenty-four, 25 kronor) are available to libraries and botanical institutions until April 1, 1951, after which any copies that might be left over will be made available to individuals. "Communication No. 4" (including the general programme) of the Congress (2 kronor) and also a limited number of copies of "A Short History of Botany in Sweden", by Rob. E. Fries (10 kronor), are generally available. These publications are obtainable from Dr. Ewert Åberg, Office of the Secretary-General, c/o Seventh International Botanical Congress, Uppsala 7.

MECHANISM OF ACTION OF ORGANO-PHOSPHORUS COMPOUNDS AS INSECTICIDES

By K. A. LORD and C. POTTER
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RECENTLY organo-phosphorus compounds have been widely used as insecticides. Those chiefly used here have been 'Parathion' or *E.*605 (main active principle O.O. diethyl O.*p*-nitrophenyl thiophosphate), hexaethyl tetraphosphate (HETP) and tetraethyl pyrophosphate (TEPP). Hall and Jacobson[1], and Dvornikoff and Morrill[2], have published data indicating that the main insecticidally active constituent of the latter two compounds is tetraethyl pyrophosphate.

These materials have a high mammalian toxicity, generally attributed to their activity as anticholinesterase agents. It has also been shown that they inhibit insect cholinesterases[3-5]. However, the toxicity of tetraethyl pyrophosphate and 'Parathion' as contact insecticides cannot be directly related to their activity as anticholine esterases, since the former is the more potent enzyme inhibitor whereas, in many instances at least, 'Parathion' is the more potent insecticide.

Some preliminary investigations with extracts of adult *Tribolium castaneum* Hbst. and larvæ of *Tenebrio molitor* L. demonstrated the ability of these extracts to hydrolyse ethyl butyrate and *o*-nitrophenyl acetate, but not acetylcholine. Furthermore, hydrolysis was inhibited by tetraethyl pyrophosphate-containing materials.

Further experiments with extracts of a number of insect species in different stages of development, namely, eggs and larvæ of *Diataraxia oleracea* L. (tomato moth), eggs of *Ephestia kühniella* Zell (Mediterranean flour moth), larvæ of *Plutella maculipennis* Curt (diamond black moth) and the apterous viviparous parthenogenetic females of *Macrosiphum euphorbiæ* Thos. and *Acyrthosiphon pisum* Harris, showed that they all possessed the ability to hydrolyse *o*-nitrophenyl acetate and that hydrolysis was inhibited by tetraethyl pyrophosphate-containing materials at low concentrations.

From this work it appeared that the inhibition of esterases other than choline esterase might play an important part in the mechanism of action of the organo-phosphorus compounds. A study was then made of the correlation between the capacity of ten samples of materials containing different amounts of tetraethyl pyrophosphate to inhibit the esterase activity of an extract of *Tenebrio molitor* L. larvæ and their toxicity as contact insecticides to adult *Tribolium castaneum* Hbst. The results of these experiments, which are summarized in Table 1, suggest that tetraethyl pyrophosphate content, esterase inhibition and contact insecticidal activity are interdependent, although there is a rather closer correlation between content and esterase inhibition than between content and contact toxicity.

Table 1. CORRELATION BETWEEN TETRAETHYL PYROPHOSPHATE-CONTENT, CONTACT INSECTICIDAL ACTIVITY AND ANTI-ESTERASE CAPACITY FOR THREE INSECT SPECIES

Sample No.	T.E.P.P. content (% w/v)	Relative anti-esterase activity	Relative potency* as contact insecticides		
			T. castaneum adults	*M. euphorbiæ* apterous viviparous partheno-genetic females	*P. maculi-pennis* final instar larvæ
1	6·2	6	18	22·6	20·0
2	11·6	18	30	29·2	25·6
3	11·8	15	28	39·4	33·2
4	15·0	25	36	36	36
5	18·2	32	34	—	—
6	20·2	40	44	51·6	32·6
7	28·0	40	70	79·5	—
8	40·2	44	59	—	—
9	63·5	79	93·5	—	—
10	75·1	100	92·5	—	—

* Sample No. 4 was taken as the standard of reference.

Table 2. A COMPARISON BETWEEN THE RELATIVE ANTI-ESTERASE ACTIVITY OF 'PARATHION' AND TETRAETHYL PYROPHOSPHATE-CONTAINING MATERIALS AND THEIR RELATIVE CONTACT INSECTICIDAL ACTIVITY

	'Parathion'	Sample No. 7 TEPP content 28% w/v	Sample No. 8 TEPP content 40·25% w/v
Relative anti-esterase activity	1	2·4	2·6
Relative toxicity *Tribolium castaneum* Hbst., adults	27	—	1
Relative toxicity *Phaedon cochlariæ* Fab., adults	25*	—	1*
Relative toxicity *Plutella maculipennis* Curt., larvæ	6*	—	1*
Relative toxicity *Diataraxia oleracea* L., eggs	29	1	—
Relative toxicity *Ephestia kühniella* Zell, eggs	125	1	—

* Probit regression lines not parallel relative toxicity measured at the M.L.C.

Tetraethyl pyrophosphate-containing materials have also been shown to be toxic to eggs of *Diataraxia oleracea* L. and *Ephestia kühniella* Zell, which contain enzymes hydrolysing *o*-nitrophenyl acetate and inhibited by tetraethyl pyrophosphate. High concentrations of the poison were required to obtain a high mortality; but it was capable of killing the eggs at an early stage of development before the differentiation of the nervous system. These results also suggest that enzymes other than cholinesterase of the nervous system may be important in the poisoning of insects by these materials.

The contact insecticidal activity and anti-esterase activity of 'Parathion' was compared with that of tetraethyl pyrophosphate-containing materials (see Table 2). It was found (in agreement with other authors using cholinesterase) that whereas the tetraethyl pyrophosphate-containing materials were more potent enzyme inhibitors than 'Parathion', the latter was considerably more potent as a contact insecticide to five species of insects used. It is suggested that the tetraethyl pyrophosphate-containing materials are less effective as contact insecticides than 'Parathion', although they are more potent esterase inhibitors, because they are unstable and hydrolyse rapidly. This view is supported by experimental data, obtained here, showing that tetraethyl pyrophosphate may act more rapidly than 'Parathion', when applied as a dust at high concentrations. Under these conditions, comparatively large amounts of toxicant are present and toxic action is rapid, so that

hydrolysis during the process of penetration to the site of action and at the site of action may be expected to be of minor importance. Reduction of the concentration below a certain critical value results in an increase in the time for a reaction to occur; in these circumstances, instability apparently becomes of importance, since below a certain concentration tetraethyl pyrophosphate is non-toxic although the more stable 'Parathion' is toxic at much lower concentrations, the time for a reaction to occur increasing progressively as the concentration is reduced.

It is proposed to publish a full account of this work elsewhere. [Aug. 2.

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WATER AT A DEPTH OF — 5 FT. DISCOVERED BY DIVING IN PEAK CAVERN

By Dr. R. E. DAVIES
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DURING the exploration of the completely flooded Buxton Water Passage of Peak Cavern, Castleton, Derbyshire, on August 17, 1947, a chamber in the roof was discovered (Fig. 1), 300 ft. from the diving base, in which the water at the top was 5 ft. 7 in. above the nearby free air–water surface in the cave.

The exploration was made using diving dresses and self-contained oxygen-breathing apparatus, and depth was measured with Bourdon gauges. This place has been named the Torricellian Chamber, and the following observations exclude water pumps, Venturi effects or gas-fixing micro-organisms as the cause of this novel phenomenon. The walls of the Chamber are smooth, have erosion facets, and are free from holes. The velocity of the water in the flooded passage below the Chamber is normally only about 1 in./sec. Samples of the water and scrapings from the walls contained the normal and negligible amount of water organisms when tested bacteriologically, and showed no uptake of gas when shaken in air in standard Warburg manometers.

Regular observations of the Torricellian Chamber were made for many months with the results shown in Fig. 2. When gas was released into the Chamber, either from the diving equipment or by means of a hosepipe from the nearby Forward Halt 1, it was found that it remained *in situ* for months during normal conditions, but was entirely removed by the major floods which occasionally fill the cavern. Minor floods were less effective. Two questions must be answered: how is the water-level raised, and how is it maintained? Fig. 2 shows that the raising of the water-level follows the flooding of the cave and that the level remains constant (± 1 in.) whatever its height in the intervening periods.

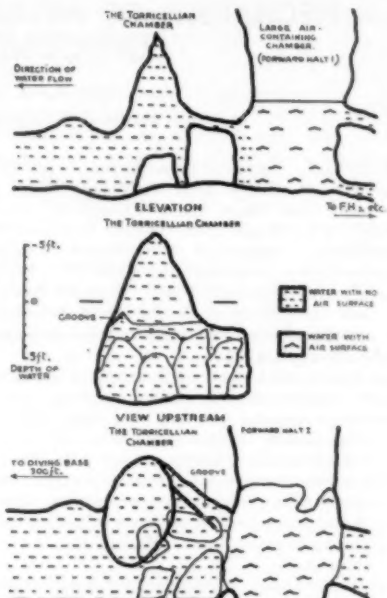


Fig. 1. Elevation, view upstream, and plan of the Torricellian Chamber in the Buxton Water Passage of Peak Cavern

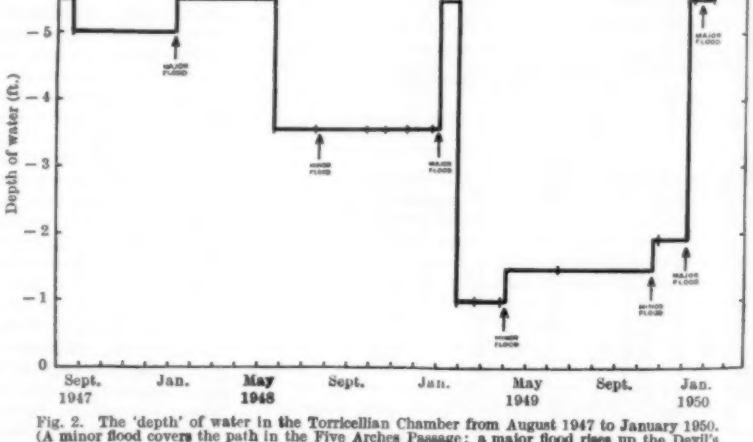


Fig. 2. The 'depth' of water in the Torricellian Chamber from August 1947 to January 1950. (A minor flood covers the path in the Five Arches Passage; a major flood rises up the Devil's Staircase and fills the whole Cavern.)

Since the local cave water is saturated with air at 1 atm., the system cannot be in equilibrium and air should diffuse out of the water and so fill the Chamber. The diffusion constant of air in water at the cave temperature of 8° C. is $1{\cdot}4 \times 10^{-5}$ c.c. gas at N.T.P./cm.²/min. at a pressure gradient of 1 atm./cm.[1]. Thus even if as little as the top 1 cm. of the water were stagnant, the water-level would fall at only about 1 cm./year. A model can be made by leaving an inverted test-tube full of water in a small water-filled beaker. It takes many months for the water-level to fall and reach equilibrium. That such natural unequilibrated air pockets can persist for long periods was also shown by the discovery, in the Swine Hole – Resurgence Passage, of an air–water surface below a conical pocket in the roof at a depth of 11 ft. This pocket could be filled by bubbles carried along during floods; but the air dissolves so slowly during normal conditions that it was full of air although there had been no floods for months.

Another proof that the air–water system in the Torricellian Chamber is not in equilibrium was shown after gas from the breathing apparatus had been released into the Chamber on May 16, 1948, and samples of the gas collected on October 17, 1948, from the Chamber, Forward Halt 1 (Fig. 1), and a bubble on the roof of the Buxton Water Passage at a depth of 5 ft. Analyses showed these contained 29·4, 19·3 and 17·6 per cent oxygen respectively. Oxygen is more soluble in water than nitrogen, so the low values in the dissolving bubble and in Forward Halt 1, where the air had been breathed for some hours, are therefore expected. The high value in the Chamber shows that even after five months the oxygen released had not reached equilibrium with the water. The problem of the maintenance of these water-levels is therefore satisfactorily explained by the slowness of diffusion in the conditions which obtain in the flooded part of the cave.

The actual removal of the air is associated with major floods (Fig. 2), and it is possible that during these floods a whirlpool is formed and the air in the chamber passed down the vortex and carried away down the passage. A detailed examination showed that a gap in the pile of boulders just upstream from the Chamber could direct a jet of water obliquely upwards which would hit one side of the rock and start a whirlpool, and that there is an eroded inverted V-groove in the rock roof from this gap to the edge of the Chamber. Experiments with a jet of water from a normal laboratory tap showed that air could be removed down a vortex in even such a disadvantageous shape as that of a standard 1-litre measuring cylinder, which could be filled when upside down if its rim were dipped into water. Water spirals up round the walls and then down the centre with greatly increased velocity. It has a narrow, irregular hollow core down which the air escapes. During major floods, so much water passes through Peak Cavern that velocities greater than 20 m.p.h. certainly occur by the boulder jam near the Torricellian Chamber. Dr. G. K. T. Conn, of the Physics Department, University of Sheffield, has calculated that this velocity is amply sufficient to produce instability in the Rankine vortex formed in the Chamber, so that the pumping action would begin and remove all the air. When the flood subsides the Chamber will be left completely full of water.

A final proof that a whirlpool is formed was obtained on January 7, 1950, when the Chamber was visited during an incipient flood. Handfuls of mud from the floor of the Passage were released into it, and this showed that the water was swirling round slowly. There had been a major flood on December 19, 1949, and there was no trace of air in the Chamber.

The formation of a system with water at a depth of −5 ft. 7 in. in this Chamber in Peak Cavern is thus explicable on the basis of the occurrence of whirlpools during the periodic floods, and the maintenance depends on the slowness of diffusion relative to the interval between floods.

These observations were made by or with the co-operation of the following members of the Cave Diving Group: F. G. Balcombe, D. A. Coase, W. H. Davis, G. W. Mack and J. A. Thompson. We wish to thank the Duchy of Lancaster for permission to explore Peak Cavern, and the custodian, and members of the Sheffield University Mountaineering Club for assistance. [Aug. 11.

[1] "International Critical Tables", 5, 62.

BRITISH PHARMACEUTICAL CONFERENCE, 1950

THE eighty-seventh British Pharmaceutical Conference was held in Glasgow in September 1950 and was attended by more than six hundred persons. The chairman, Mr. A. B. Powell, appropriately took as the subject of his address, progress in the pharmaceutical field during the past half a century. Advances, he stated, have run parallel with, and have been influenced by, advances in the cognate sciences of chemistry, physics and medicine, and are reflected in the present emphasis on preventative treatment, such as the use of vitamins, and on devising compounds with specific action against the causal organisms of disease, rather than on the palliatives formerly used chiefly for the relief of symptoms. This change can be readily seen if a modern pharmacopœia be compared with one of fifty years ago. The plasters and pill masses have disappeared and a host of new drugs and preparations appear, such as antibiotics, sera and vaccines, œstrogens, insulin, liver preparations, heparin and hormones. The introduction of a large number of injections for parenteral use indicates a further change, namely, in the method of administration of drugs.

The study of the constitution of naturally occurring compounds of proved activity gradually led to the knowledge of the effects of certain molecular groupings, and in turn to the development of chemotherapy. Chemotherapeutical research is directed to the production of compounds with toxic effects against invading organisms, yet without harmful effects on the host. Some early results of this new approach still play a large part in modern treatment, for example, aspirin, procaine, barbiturates and mepacrine. Later, Domagk (1935) discovered the antibacterial activity of prontosil and thus initiated the enormous amount of research work which has produced the variety of sulphonamides now available. The discovery of penicillin has opened up in a like manner an entirely new range of remedial products—the antibiotics. The use of these new types of drugs has stimulated advances in methods of formulation and administration, in methods of biological assay, in analytical technique, and in methods of controlling purity using physical

instruments such as the spectrophotometer and fluorimeter.

These rather spectacular advances in the treatment of disease, however, may give us a distorted picture of the situation unless we remember that the mass of knowledge of the older drugs which has accumulated over the centuries is still being added to and used in modern treatment. It is needful to recall the warning given by a famous physician "not to dismiss the accumulated experience of 3,000 years on the evidence of the latest galvanometer reading". Mr. Powell concluded his address by demonstrating the effect which legislation and progress in social welfare during the past half-century have had upon the practice of pharmacy.

The research papers which were read and discussed at the science sessions formed an interesting commentary on the chairman's address. While several of the papers were concerned with the newer drugs such as acridines, vitamin B_{12}, heparin and blood plasma, there was a number concerned with the constituents, preparations and evaluation of the older drugs. Further papers dealt with the problems involved in the newer methods of formulation, production and analysis of pharmaceutical materials.

A paper on the tuberculostatic activity of some semithio carbazones (E. M. Bavin *et al.*) well illustrated the fact that the incorporation of the chemical characters of two therapeutically active compounds into one molecule cannot be relied upon to produce an active resultant. Those compounds, which represent a combination of the two active substances 4-amino-salicylic acid and 4-acetamidobenzaldehyde thiosemicarbazone and which would be expected to be highly active, were found to be inactive. Attempts to overcome this loss of activity by blocking possible hydrogen-bonding effects were unsuccessful. Incidentally, the *in vivo* activities of these compounds were tested by the comparatively rapid 'corneal test' and 'survival test', both of which were found to be satisfactory. In another paper, R. C. Kaye recorded the results of a polarographic study of the redox characters of the amino acridines, and suggested that the bacteriostatic effects of these drugs may be due to their ability to accept electrons to form stable free radicals; such binding of fugitive electrons would tend to terminate chain reactions essential to the life of the bacterial cell. Vitamin B_{12}, the recent isolation and use of which have occasioned much interest, was the subject of a paper concerned with the important problems of the control of its purity and its stability, especially during the sterilization of aqueous solutions intended for injection.

The papers which dealt with the older drugs showed that in this field there is still a considerable amount of research necessary so that the most effectual use can be made of naturally occurring remedies. Pelletierine tannate of the British Pharmacopœia was shown to bear little resemblance to the original alkaloids present in *Punica granata*, from which it is prepared. The present methods of manufacture lead to changes in the naturally occurring alkaloids and result in a great loss in their therapeutic activity. Two papers on senna pod furnished scientific evidence for the general opinion that the fresh infusion is the most active preparation of this drug; they also showed that the concentrated preparations of the British Pharmacopœia have low activity, and stated the principles on which active concentrated extracts could be made. Two independent papers on pancreatin criticized the British Pharmacopœia method of assaying this animal product and suggested improved methods the use of which should result in products of reasonable activity and uniform potency being marketed.

The problems which arise as a result of improvements in pharmaceutical practice were reflected in those papers which dealt with tablet making, bacterial survival during spray-drying processes, the sterilization of the oily basis of thermo-labile drugs and the preparation of liquid human plasma.

The introduction of new ancillary materials also brought new items for investigation, for example, the use of alginic acid in tablet making and the use of non-ionic detergents in the manufacture of emulsions and creams.

J. W. FAIRBAIRN

SOCIETY FOR APPLIED BACTERIOLOGY

ANNUAL GENERAL MEETING

THE twenty-first annual general meeting and conference of the Society for Applied Bacteriology was held at the University of Nottingham during September 20–23. More than ninety members and guests attended one or more sessions of the conference. The resignation of the editor of the *Proceedings* of the Society, Dr. T. Richards, of the University of Reading, was announced, and Dr. S. E. Jacobs, of the Imperial College of Science and Technology, London, and Dr. L. F. L. Clegg, of the Ministry of Agriculture, Wolverhampton, were appointed joint editors. Eleven papers and four demonstrations were presented during the three paper-reading periods, and these will appear in full in the *Proceedings* in due course.

Dr. Jacobs gave results of experiments on bacterial control of the flour moth (*Ephestia kuehniella* Z.). The normal method of dealing with this pest is fumigation. In laboratory experiments, using a proprietary bacterial spore powder, it was found that considerable mortality occurred among larvæ exposed to a 3·0 per cent concentration, but that at 1·0 per cent the result was not so effective. Further experiments showed that concentrations of 0·5 and 0·3 per cent completely prevented development of young larvæ. A larger trial in sheds showed that after sixteen weeks the flour from sheds treated with spore powder had a markedly reduced number of larvæ and moths. It was concluded that dusting with bacterial spore powder offers a measure of control and may be a useful adjunct to existing methods.

Some aspects of pollution of well-water supplies and methods for eradication were discussed by N. R. Knowles, of Queen's University, Belfast. It was shown that transformation from a polluted to a reasonably pure water supply could readily be attained by relining the upper 6–12 ft. of existing wells with concrete blocks carefully cemented together and raising the well head above ground-level to prevent surface seepage. The practice of siting wells adjacent to farm buildings cannot be recommended and should be discontinued.

Experiments designed to improve the bacteriological control tests of ice-cream in Northern Ireland formed the basis of a paper from J. Patton, of Queen's University, Belfast. Four conclusions were suggested: that boxes containing solid carbon dioxide

should be used for transporting ice-cream samples; that the minimum time/temperature for the pasteurization of ice-cream mixes should be 165° F. for ten minutes; that the gravimetric method of preparing the initial dilution for colony counts should be used rather than volumetric measuring, since the former gives a more reproducible result; and that the present plate-count and coliform tests provide better information for determining the hygienic quality of ice-cream than the methylene blue test.

A note on bacterial die-back and canker of poplar was presented by K. A. Sabet, of the Botany School, Cambridge. This disease, which does not appear to have been critically studied in Great Britain, was first recorded in Britain in 1923. The condition is attributed to a *forma speciales—Pseudomonas syringæ (van Hall) f. sp. Nov.* The presence of bacterial slime is essential for the organism to establish itself in the host tissues and produce typical symptoms. Infection, which develops slowly, takes place in early summer only.

The effect of overnight refrigeration on the results of the bacteriological examination of farm water supplies has been investigated by G. E. Jones, Miss P. M. Franklin and S. B. Thomas, of the National Agricultural Advisory Service (Wales). Their results showed that about twenty per cent of water samples examined twenty hours after sampling, following eighteen hours of storage at 3–5° C., had a significantly lower coliform content when compared with determinations made at two hours. Samples with more than 50 coliform organisms per 100 ml. of water at the initial testing time seldom showed an increased content after refrigeration overnight. These results confirm the findings of other workers. The colony count at 37° and 22° C. did not reflect this reduction in numbers.

Miss R. E. A. Allen, of King's College, Newcastle, described types of micro-organisms isolated from the rotting surface of water-proofed rope. Using soil-burial tests, Miss Allen isolated ten distinct mould strains and seventy-one bacterial species of which five were Gram-positive and sixty-six Gram-negative rods. No cocci were isolated. *Pseudomonas* sp. predominated among the Gram-negative rods. The water-repellent was capable of supporting a varied flora of Gram-negative bacteria.

An analysis of farm milk rejections over the past six years was presented by Miss C. Campion, I. A. Howard and Miss B. M. Fischer, of Job's Dairies, Feltham. While during this period many supplies were rejected due to taints, the majority were rejected for simple souring, and no single factor, common to all producers, could account for the rejections. The conclusion was reached that milk of acceptable quality can readily be given under existing methods of production and that this quality is within the control of the milk producer himself.

The value of high-frequency electric fields as a method for large-scale efficient sterilization at non-lethal temperatures has attracted the attention of a number of investigators. Dr. S. E. Jacobs, Miss M. J. Thornley and P. Maurice, of the Imperial College of Science and Technology, London, presented a short paper on some experiments designed to study bacterial survival in high-frequency electric fields. The conclusion was reached that the high-frequency techniques at present available fail to induce high mortality. It is possible that a marked effect might be obtained only at highly critical frequencies since all complex molecules have natural frequencies of oscillation, and if an intense field could be applied at the right frequency it might be possible to disrupt the bacterial cell. So far such an effect has not been observed.

Three papers were presented by workers in the Research Department of Messrs. Boots, Nottingham. The treatment of infections with combinations of chemotherapeutic agents was discussed by B. H. Chantrill. The results illustrated the efficiency of penicillin against streptococci and its ineffectiveness against salmonella. Streptomycin was shown to be reasonably active against salmonella, and more so than penicillin. In mixed infections penicillin is a disappointing therapeutic agent. With penicillin and streptomycin in a mixed infection, a well-marked synergic effect occurs.

In the second paper Miss B. Croshaw discussed the experimental evaluation of anti-tuberculosis drugs. The guinea pig test is considered the most reliable and gives a reproducible result; but a susceptible strain of mice produces a quicker test and requires much less of the drug. In Miss Croshaw's experiments the intracerebral method of injection of mice was used, and a more uniform infection obtained. This method is now being tried with various drugs, the activity of the drug being assessed by the extent of lung involvement when the animals are killed after treatment.

The third paper, by A. Royce and G. Sykes, reviewed aspects of sterilization by candle filtration. It was found that the bubble pressure response of a filter candle can be used as a reliable indication of its filtration efficiency and that a response of 17 lb./sq. in. or more will safely filter sterile a nutrient solution over a period of seventeen hours. This conclusion may require to be modified if solutions containing wetting-agents are involved.

Two demonstrations from the Research Department of Messrs. Boots dealt with the culture of viruses in eggs, by L. Dickinson, and the microbiological assay of antibiotics and vitamins, by D. G. Lewis and F. M. Mulholland. Miss B. M. Fischer (Job's Dairies, Feltham) and Miss M. Fielding (Nottingham Co-operative Society) showed the complete Astell roll tube apparatus, and G. E. Jones (Wye) demonstrated the preparation of a modified pectate gel medium.

CONTROL OF ELECTRICAL MACHINES

A VACATION school on the control of electrical machines was held in the Electrical Engineering Department of the Imperial College of Science and Technology, London, during September 18–22. The school, which was under the chairmanship of Prof. Willis Jackson, was attended by some sixty engineers, drawn from industry, research associations, the universities and technical colleges.

The opening address was given by Mr. W. M. Couch, deputy director of electrical engineering at the Admiralty, who referred to the rapid developments being made in electrical engineering and the need for exchange of ideas. He said that the increasing use of automatic control equipment will aid productivity, and the study of the common basis of the many techniques in use is very opportune. Mr. B. Adkins, of the British Thomson-Houston Co., Ltd.,

discussed in the first lecture the general principles of the subject, giving illustrations of open-loop and closed-loop systems and outlining the mathematical techniques employed in their analysis. During the discussion the need for improved nomenclature was voiced, and the respective spheres of application of the Laplace transform and Heaviside's operational calculus were discussed.

In the next lecture, Mr. M. W. Humphrey Davies, of Imperial College, described the action and properties of the several forms of two-stage machines used in rotating amplifiers. In the ensuing discussion attention was directed to the proportionality between the inherent time-constant and power amplification in these machines. Mr. D. Wray, of the English Electric Co., Ltd., spoke next on magnetic amplifiers, giving the outline theory of their action and a review of their principal applications. Their use in push-pull, and dependence on supply voltage, were later discussed. Lecturing on electronic amplifiers, Dr. W. G. Thompson, of the General Electric Co., Ltd., showed how grid control of thyratrons or mercury-arc rectifiers would give flexible control schemes. The advantages and disadvantages of electronic methods were compared, and discussion continued on the different techniques needed with electronic devices, and the need for special training of maintenance staff.

Large D.C. machines, their design limitations and the controls which can be coupled without external amplifiers, were then discussed by Mr. E. P. Hill, of the Metropolitan-Vickers Electrical Co., Ltd. The effects of iron paths and coupled circuits on time-constants were treated in the discussion. Mr. A. A. L. Bentall, of the Metropolitan-Vickers Electrical Co., Ltd., followed, illustrating the control of D.C. machines in various combinations with a wide selection of industrial applications. The great flexibility of these machines was emphasized and invoked a varied discussion on their industrial uses. The control of A.C. machines was dealt with by Mr. A. Asbury, of the English Electric Co., Ltd., who outlined the methods of controlling large induction and synchronous motors which find particular application where the largest powers are required. Questions of dynamic braking and unbalanced voltage control were raised in the discussion, during which the smaller A.C. machines also received some consideration.

On September 21 a visit was paid to the Kemsley Paper Mill of the Bowater Lloyd Pulp and Paper Mills, Ltd., where examples of the control of electrical machinery were described and illustrated by Mr. A. C. G. Witts and his colleagues of the Bowater organisation. The automatic control schemes for paper machines and wood grinders were of particular interest.

On the concluding day, Mr. W. Spence, of the British Thomson-Houston Co., Ltd., gave a concise summary of the methods of combining control apparatus into a complete closed-loop control system and of assessing the resulting performance. The discussion emphasized the necessity for close collaboration between machine designers, control engineers and users. Mr. A. Asbury dealt finally with the calculation and measurement of the constants of electrical machines and methods for testing a complete control cycle. It was clear from the examples quoted in the discussion that calculated and measured constants are frequently at variance, and methods for reducing the discrepancies were suggested.

The general impression given from the whole course was that rapid progress is being made in the design of control systems and in the appraisal of the relative merits of different schemes. There is still, however, need for a better appreciation by users of the importance of specifying their performance requirements as precisely as possible, and for not asking for a closer control than is really necessary, if they require an economical system.

FINANCIAL INCENTIVES

IT is generally recognized in industry that the provision of adequate incentives for the ordinary worker is one of the ways to improved industrial production. The most obvious and, to some, the most satisfactory form of incentive is more money for better work. For this reason there has been a marked growth of interest in industry, and particularly among the smaller firms, in the introduction of financial incentives schemes. The British Institute of Management has therefore issued a pamphlet describing the most popular wage incentive scheme, methods which have been suggested for introducing and applying them, and elaborating the conditions necessary to their success*.

Before an employer or manager introduces a new financial incentive scheme, it is emphasized that he should first ensure that the tooling, layout, material and finished goods, servicing and general methods of production cannot be improved within the limitations of capital expenditure available. Neither will a new wage incentive system be successful unless good relations exist between management and workers. The scheme should be introduced gradually after effective consultation with the workers, while all supervisors should be informed in the early stages of all details of the scheme. Collective agreements in the industry governing the fixing of basic rates and minimum piecework guarantees should be considered, and rates governing the scheme must cover all possible contingencies.

When the ground has been prepared, the particular scheme to be introduced must be carefully selected, having regard to factors such as the type of production in operation, for example, unit, batch or flow production, the type of labour employed, the grouping of production workers, whether or not skilled time-study operators are available, the probable continuity of supplies, materials and parts, the degree of mechanization of the process and the existing level of earnings of the workers.

Of the wide range of incentive systems which has been evolved the following are representative of the more commonly used.

First is the system of straight piece-work with a guaranteed minimum wage involving the payment of a uniform price for a unit of production; this system is suitable where production is repetitive in character and can easily be divided into similar units. The system has the advantage of being easily understood and earnings are simply calculated.

Secondly, there is the differential piece-work scheme, which is suitable where types of production are similar to those specified for straight piece-work and characterized by similar advantages and limitations. In order to enhance the incentive effect of the straight piece-work system some differential piece-work schemes include a method whereby the piece-work price is increased where normal output in a

* Organising for Output. Pp. 66. (London: British Institute of Management, 1950.) 2s. 6d.

given time is surpassed; these are useful for encouraging the less-skilled worker.

Thirdly, there are the time-saved bonus schemes in which time study is used for setting a standard time, a reward additional to a guaranteed minimum being given to employees who complete the task in less than standard time. Among these are the Gantt method, which provides for the payment of a minimum hourly rate of 66·6 per cent efficiency on the specified task, at which point the rate begins to increase on a graduated scale. The scheme is useful for machine jobs liable to delay and where expensive machines are operated. Under Emmerson's efficiency method a time is fixed for the job, and the outstanding worker who is able to complete it in this time is regarded as 100 per cent efficient or as representing the unit of efficiency. Where a worker takes longer than the allowed time a calculation of his efficiency is made. For any efficiency in excess of 66·6 per cent (which represents the minimum time-rate) a bonus is paid on a sliding scale, yielding 10 per cent bonus on 90 per cent efficiency. The scheme is useful for gradual transition from day-work to a high-incentive piece-work plan.

Schemes of a similar nature include the Halsey system, the Rowan system and the standard hour plan.

Fourthly, there is the point system, which introduces a new element into wage incentive systems. In place of task times and production units, the point system evaluates a piece of work in time units which purport to take account of the amount of skill and energy required for its efficient performance and also for the amount of rest an average worker needs during its performance. In one scheme, for example, the unit of one minute represents the expenditure of energy plus allowance for recovery, there being sixty units in an hour. The number of units represented by each operation must be determined by work study, and this inevitably involves the employment of skilled work-study engineers. The plan is somewhat more expensive to install and administer than other schemes, and may prove complicated and difficult for workers to understand.

The payment systems already described relate the award to the effort of the individual worker. There are, however, many situations in industry where work is carried out by teams in which the individual efforts of each worker are conditioned by the efforts of the other members of the team. To meet such situations, many forms of group incentives have been devised. The major problem is to devise a method of distributing group incentive payments that will be acceptable to all the members of the group. The Priestman bonus scheme is one of the more common group incentive schemes which are used in Britain. It is based on the principle that, if a given number of men in a given time, when working under ordinary methods and at day-rate, are capable of producing a certain quantity and type of finished goods (called the standard output) then, if by greater collective effort without increasing the number of men or their hours of working the workers can increase this output, a percentage is added to their day-rate equivalent to that by which the standard output has been increased. Group incentive schemes have three main applications in which they may be superior to individual piece-work systems:

(1) Conveyor-work where operators cannot produce any more work than is passed to them by the operators preceding them on the line of production.

(2) Work other than on conveyor where quality and handling of an operation can greatly affect the subsequent operation.

(3) Work of such a varied nature, both as to kind and quantity, as to make individual measurement impracticable or excessively expensive.

There is, however, a growing number of people in industrial management which holds that for several reasons, payment-by-result schemes, whether individual or group, fail to exercise the maximum possible overall incentive effect. It is wrong, they argue, that all reward should be directed only towards the quantity of work produced. There are many other qualities which go to make the best type of worker which may be overlooked if quantity of work is to be the sole criterion of an efficient employee.

For these reasons, in recent years, a few undertakings have been seeking for a more equitable and acceptable basis of payment. One method which is winning growing recognition and adoption is the individual assessment bonus scheme. This starts with an arrangement to pay to every worker as a minimum the time-rates fixed by collective agreement in the industry. To this is added a sum which is based on a very careful assessment of each worker in respect of a number of qualities displayed by him. The qualities assessed will probably include regular attendance at work, punctual starting, saving of time, quantity of work as observed over the review period of three or six months, team work and co-operation with colleagues and supervision, personal conduct, care of the company's equipment and tools, general ability and aptitude, saving of materials and quality of work. Each of the qualities selected is allotted a number of points, these being weighted in accordance with their importance. The scheme presents a simple means of sharing with employees increased prosperity arising from improved performance.

Great care should be taken in selection of the incentive scheme to suit the particular type of production, and the booklet gives examples of schemes which might be suitable for different types of industries. Before any incentive scheme is contemplated it should be made clear that the object of incentive payment is to encourage the worker to produce his maximum output without undue fatigue.

T. H. Hawkins

EXPERIMENTAL AND RESEARCH STATION, CHESHUNT

ANNUAL REPORT FOR 1948

COMMERCIAL horticulture under glass is expanding steadily, and, in spite of the growing contribution to food supplies, such intensive cultivation brings problems of culture, nutrition and disease. The annual report for 1948 of the Experimental and Research Station, Cheshunt, Herts*, shows how the work of the Station has increased the yield of tomatoes and lettuce. Its recent trials indicate that the English tomato Downes Seedling and the Dutch variety Bruinsma gave the highest yields, at 61 tons per acre. The new Cheshunt *5B* lettuce matures eight days earlier than the Station's original introduction, Early Giant. Mushrooms grown on horse

* Experimental and Research Station, Cheshunt. Annual Report (Thirty-fourth Year), 1948. Pp. 90+4 plates. (Cheshunt: Nursery and Market Garden Industries Development Society, Ltd., 1949.)

manure compost yielded 1·9 lb. per sq. ft. against 1·2 lb. for the best of a number of 'synthetic' composts. Other features of practical culture relate to the successful growing of tomatoes in cardboard boxes treated with 'Cuprinol', the lack of disparity in yield when top-dressings are given in solid or liquid form, and the use of sulphate of ammonia as the sole source of nitrogen for the tomato crop.

The severity of disease caused by the fungus *Didymella lycopersici* seems to have no relation to manurial treatment, and excesses of magnesium, boron and manganese did not appear to influence infection (P. H. Williams). A fascinating possibility of 'curing' plants of virus diseases has been investigated by R. Howles. A spray of 1 per cent tannic acid on two consecutive days reduced by 50 per cent the number of plants infected. Solanums infected with mosaic were 'cured' by exposure to a temperature of 105° F. for twelve hours per day for four consecutive days. These findings certainly merit further investigation. A study of the identity and life-history of leaf miners on tomato seedlings, by E. R. Speyer and W. J. Parr, shows that the fly responsible is *Liriomyza solani*. A 5 per cent benzene hexachloride dust was more effective than 5 per cent DDT in destroying adult flies, but both substances can injure tomato seedlings. A study of toxicity of analogues of azobenzene against red spider mite revealed no compound more effective than azobenzene itself (W. H. Read). Hexaethyl tetraphosphate (HETP) and tetraethyl pyrophosphate (TEPP) destroyed adult red spider mites, but not the eggs of this pest. Both the last-mentioned compounds controlled aphids on carnations.

Chemical studies involve, *inter alia*, fundamental investigations into the mechanism of nitrification in glasshouse soils by O. Owen and G. W. Winsor. Experiments with added carbon show that the lower carbon/nitrogen ratio produces the higher level of nitrification. The availability of alginates raises the interesting possibility of using such substances as sources of organic carbon in soil (O. Owen). Alginic acid and sodium and calcium alginates have given promising results, though ammonium alginate may be almost toxic. Some rather variable results of trials with calcium alginate on a commercial scale, however, show that further work on the subject is needed. Changes in nitrification after steam sterilization are greatly in need of investigation, and it is gratifying to note that work on this project has commenced (J. N. Davies and O. Owen).

A mild criticism of the report is its increase in page size from octavo to quarto, which disorganises the files. This petty complaint, however, serves but to emphasize the value of the work in the report, for he who reads it desires to preserve it for future convenient reference.

EFFECT OF CERTAIN YEASTS ON SOME TUMOUR CELLS

CERTAIN strains of yeast apparently show *in vitro* a selectively destructive action on the cells of some malignant tumours, but not on those of benign tumours or of normal tissues. Dr. Giocondo Protti, of Busto Arsizio, Italy, has been working in this field since 1930 and has developed special techniques which he has recently summarized in three articles[1].

Fragments of tissue were selected from frozen sections examined by phase-contrast microscopy to ensure that only actively growing tissue free from necrosis was used. The fragments were immersed in liquid cultures of *Saccharomyces cerevisiæ* var. *ellipsoideus* and incubated at 30° C. for 48 hr. About a hundred varieties of yeast were tested, with variable results; certain varieties caused lysis of the nuclei of some tumours but were inactive for other tumours.

Controls with inactivated yeast and with medium devoid of yeast showed that incubation alone or in the presence of certain yeast metabolites did not produce comparable lysis of tumour cells.

Comparative studies on tissues incubated in contact with yeast cultures and afterwards stained with hæmatoxylin and eosin, or better, by the Feulgen technique, showed varying degrees of nuclear lysis in the case of tumour tissues. These degenerative changes could be seen also by phase-contrast microscopy. In adenocarcinoma of the alimentary canal, the nuclei of the malignant epithelium showed lysis, whereas the nuclei of the connective tissue and endothelial cells of blood vessels were relatively well preserved. Protti considers the Feulgen reaction a reliable indication, though not amounting to a quantitative measure, of the thymonucleic acid content of nuclei. The nature of the lytic action has not been determined.

In experiments with a spontaneous mammary tumour of mice of *L*-strain, 96 tissue cultures were tested against six different strains of yeast, as compared with control tissue cultures of fibroblasts (? mouse), and of retinal epithelium of 12-day chick embryos. Tumour cultures in contact with *Saccharomyces cerevisiæ* var. *ellipsoideus* *E*.14 showed little difference from control cultures and developed normally. By contrast, tumour cultures from the same material in contact with the following strains of *Saccharomyces*, *E*.4, *C*.35, *T*.54, *E*.VIII and *D*.XII, all showed arrested development and lysis of nuclei in the explants, apart from a few attempts at proliferation modified by the lytic process. Neither fibroblast nor retinal epithelium cultures showed lysis.

The mechanical effect of the yeast particles was controlled by the addition of inert powders, for example, talc or carborundum, in place of yeast cultures. Such additions had no effect on the growth of either tumour or normal tissues in culture. Altogether, 637 experiments gave similar results. Three strains of yeast, *E*.4, *E*.14 and *E*.VIII, showed no biochemical differences; but *E*.14 was inactive, while the other two caused lysis of tumour explant.

The lytic effects observed were quite different in appearance from necrobiotic effects on the tumour as shown by the Feulgen technique. Protti considers that the selective lytic action of certain yeasts on certain tumour cells indicates a metabolic difference between tumour and normal cells. In the discussion of his work he expresses the hope that his observations may eventually lead to some form of specific treatment.

It might be objected that normal fibroblasts and chick embryo retinal epithelium may well have different metabolic reactions from mammary tumour or adenocarcinoma of the alimentary canal. Possibly tissue cultures of adolescent mouse mammary tissues and of the benign adenoma that frequently precedes adenocarcinoma of breast in mice would provide a better control when studying mouse mammary carcinoma.

P. R. P.

[1] Protti, G., *Tumori*, **22**, 222 (1948); **23**, 156 (1949); **24**, 14 (1950).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Radio-frequency Radiation from the Great Nebula in Andromeda (*M*.31).

THE experiments of Bolton and Stanley[1], and of Ryle and Smith[2,3], using a radio interferometer have shown that a significant part of the extra-terrestrial radio noise is associated with point sources with diameters of less than 6 minutes of arc. Although the majority of these sources are unidentified with visual objects, their distribution indicates that they lie in our own galaxy. Attempts to detect radio emissions from specific extra-galactic objects have hitherto been unsuccessful. In this communication we describe the results of an experiment to detect radio emissions from the Andromeda Nebula (*M*.31) using a narrow pencil-beam aerial and high-sensitivity receiving equipment.

The measurements were made at a frequency of 158·5 Mc./s. using a paraboloid aerial with an aperture of 218 ft., and a focal length of 126 ft. The beam has a width of about 2°, and by moving the primary feed it can be swung at least 15½° on either side of the zenith without serious distortion of its shape. The receiving equipment employed a system in which the power from the aerial was balanced by means of a servo system against the power from a calibrated source, and was similar to that described by Ryle and Vonberg[4]. The minimum detectable power corresponded to a change in effective temperature of the aerial of about 2° K. This allows for a loss of 50 per cent of the aerial power in the feeder system and represents 1/1,500 of the noise in the equipment. The experiment was carried out by fixing the beam at a number of different elevations corresponding to the region around *M*.31, so that for each diurnal rotation of the earth the beam swept out a strip of sky 2° wide in declination and 24 hr. in right ascension. The intensity of the radiation was recorded for a series of six strips at declinations between 38° N. and 43° N.

Fig. 1 shows the results of these observations for the period 23 h. 40 m. to 01 h. 20 m. in right ascension. In order to show clearly the change in intensity with right ascension along each sweep, the records have been displaced by an arbitrary amount, corresponding to different declinations, so that the ordinate represents only the relative intensities for the points in each sweep. The sweeps between declinations 40° 18′ and 40° 52′ show a pronounced maximum in intensity at 00 h. 40 m. R.A., indicating a localized source of radiation in this neighbourhood. A full analysis of the results from all the sweeps, taking into account the gradient of the galactic background radiation in this region, yields the data for this source given in Table 1.

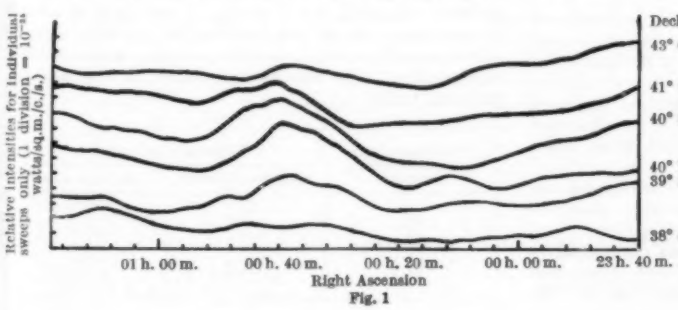


Fig. 1

Table 1. DATA ON SOURCE

Right Ascension	00 hr. 40 min. ± 2 min.
Declination	40° 55′ North ± 20′
*Intensity	4 × 10^{-23} watts/sq.m./c./s. ± 25 per cent
Apparent angular dimensions	25′ ± 10′ (declination axis) × 45′ ± 10′ (right ascension axis)

* Calculated for an equivalent point source. The error introduced by neglecting the finite size of the source is small compared with the errors of measurement.

The celestial co-ordinates of this source lie close to the centre of the Andromeda Nebula *M*.31 (R.A. 00 h. 40 m., dec. 40° 59′ N.). The dimensions of the source were measured by comparison with the apparent diameter of two sources at approximately the same declination as *M*.31, thus eliminating any error due to possible distortion of the beam. The

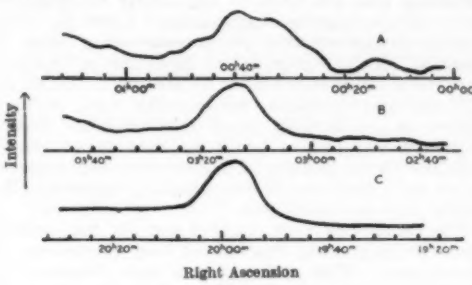


Fig. 2

diameter of one of these sources, in Cygnus, is known[1,4] to be less than 6′, which is small compared with the beam-width of 2° used in these experiments. The extension of the Cygnus source on the records will therefore correspond to the width of the beam. Fig. 2 shows the intensity recorded for a short period of right ascension during the transit of three different sources through the beam. Curve *A* shows the transit of the source in Andromeda. Curve *B* shows the transit of a point source of intensity comparable to that of the Andromeda source, while curve *C* shows the transit of the intense point source in Cygnus. The scale of intensity for each diagram has been adjusted so that the widths in right ascension of the records can be compared easily. From these records it can be seen that the source in Andromeda shows an extension in right ascension greater than that of a point source. The width of the source in declination was found by comparing its variation in intensity with declination with that of the point source in Cygnus. Table 2 gives the comparison between the apparent width to half-power of the Cygnus and Andromeda sources.

These records therefore show that the source must have a disk of apparent dimensions ½° × ½° along the right ascension and declination axes respectively. There is a chance that the apparent extension of the source is due to the fortuitous presence of

Table 2. APPARENT WIDTH TO HALF-POWER OF THE SOURCES IN CYGNUS AND ANDROMEDA

Cygnus	2° 04′ (declination) × 1° 53′ (right ascension)
Andromeda	2° 54′ (declination) × 3° 23′ (right ascension)

two or more point sources of the appropriate intensity in the beam with their effective centre coincident with that of *M*.31. From a study of the available information about point sources, it can be shown that the chance of such a coincidence is less than 1 in 4,000.

It is of interest to compare the radiation from this nebula with that to be expected from our own galaxy. Inspection of the contours given by Reber[5] on 160 Mc./s., and by Bolton and Westfold[6] on 100 Mc./s., indicates that the radiation from our own galaxy is concentrated towards the centre, and at a distance of 750,000 light years with the inclination of *M*.31 it would appear as a source with apparent dimensions of about $\frac{1}{2}° \times \frac{1}{2}°$ along the right ascension and declination axes. Also, from the measured size of the disk and the intensity of Andromeda given in Table 1, it can be calculated that the effective black-body temperature of the nebula must be of the order of 1,000° K. This is to be compared with the corresponding value of 1,500° K. for the centre of our local galaxy deduced from the measurements made by Reber[5] on 160 Mc./s.

These measurements demonstrate with a high degree of probability that extra-galactic radio-frequency radiation is being received on the earth from the Great Nebula in Andromeda, and that, so far as radio emission is concerned, it appears to be similar to our own galaxy.

This work has been carried out at the Jodrell Bank Experimental Station of the University of Manchester. The aerial system was designed by Dr. J. A. Clegg, and we wish to thank Dr. A. C. B. Lovell for its use in this investigation. One of us (R. H. B.) is indebted to I.C.I., Ltd., for a research fellowship, and the other (C. H.) to the Department of Scientific and Industrial Research for a maintenance grant.

R. HANBURY BROWN
C. HAZARD

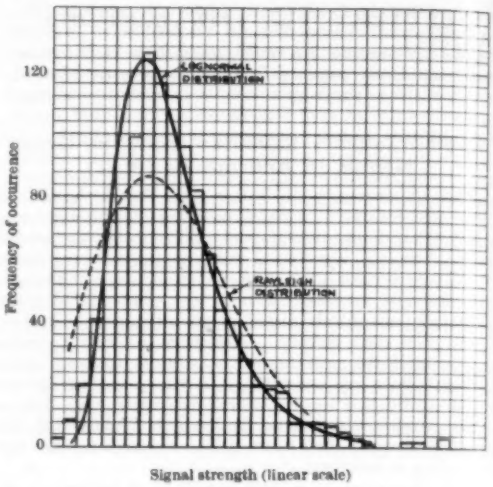
University of Manchester.
Oct. 13.

[1] Bolton and Stanley, *Nature*, **161**, 312 (1948); **162**, 141 (1948).
[2] Ryle and Smith, *Nature*, **162**, 462 (1948).
[3] Ryle, *Phys. Soc. Rep. Prog. Phys.*, **13**, 184 (1950).
[4] Ryle and Vonberg, *Proc. Roy. Soc.*, A, **193**, 98 (1948).
[5] Reber, *Astrophys. J.*, **100**, 279 (1944).
[6] Bolton and Westfold, *Aust. J. Sci. Res.*, **3**, 19 (1950).

Variability of Sky-Wave Radio Signals under Conditions of Ionospheric Absorption

AN investigation is being made into ionospheric absorption, in which the instantaneous value of signal strength of a 9·15-Mc./s. radio wave at a distance of 788 km. from the emitter is recorded once a minute. It has been found that the usually assumed Rayleigh distribution of amplitudes[1] is a poor fit to the observed distribution at times around local noon when ionospheric absorption is considerable.

The observed variations in strength of signals are much better accounted for if we assume that the absorbing region is the main controlling factor, and that the amount of absorption in this region varies randomly about a mean value. Then, since the absorption at any instant is proportional to the



logarithm of the signal strength E, the frequency distribution of signal strength values will be log-normal[2,3] in character; that is, the probability of occurrence of a value between E and $(E + \delta E)$ will be given by

$$\frac{1}{\sqrt{2\pi}\, cE} \exp\left[-\frac{1}{2c^2}\left(\log_e \frac{E}{E_0}\right)^2\right] . \delta E,$$

where E_0 is the median value of the distribution, and c^2 is the variance of $\log_e E$. The above frequency distribution, when plotted on logarithmic probability paper, will give a straight line.

Lognormal curves have been fitted to several sets of observed results. One of these is reproduced in the accompanying histogram, which shows the distribution of signal strengths measured between 1115 and 1245 hr., local time, over the period June 14–30, 1949. To reduce the effects of day-to-day variations in the mean level of signal strength, and the slow diurnal variation in absorption within each day, the recordings were divided into half-hour periods, and the readings in each period were adjusted to give an average value of 20 recorder divisions. The fitted lognormal curve is shown in full line, together with the fitted Rayleigh distribution (dotted) for comparison. A chi-square test gave a probability of 0·39 for the lognormal fit, as against a value of less than 10^{-6} for the Rayleigh fit.

A further comparison between the theoretical distributions is given by testing the ability of each to predict the value of signal strength, which is actually exceeded for a certain percentage of time; in particular, the 90 per cent and 95 per cent values, which are of practical significance in communication engineering. The results are shown in the accompanying table.

Percentage of time signal strength is exceeded	Differences in decibels	
	Lognormal–actual	Rayleigh–actual
5	0	+0·3
10	−0·1	+0·3
25	0	+0·6
75	−0·2	−1·2
90	+0·6	−2·5
95	+1·1	−3·6

From this table it is seen that the lognormal distribution gives a better estimate of all percentiles listed. For example, if we used the Rayleigh distribution to predict the 95 per cent value, the estimated emitter power would be more than twice that actually required to maintain communication.

This work forms part of the radio research programme of the Department of Scientific and Industrial Research, New Zealand, and it is reported with the permission of the Secretary of the Department. A full account of the investigation will be published elsewhere.

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July 14.

[1] See, for example, "Ionospheric Radio Propagation" (National Bureau of Standards Circular 462, Washington, 1948).
[2] McAllister, *Proc. Roy. Soc.*, **29**, 367 (1879).
[3] Yuan, *Ann. Math. Stats.*, **4**, 30 (1933).

High-Current Gas Discharge at Low Pressures

It has been found that the self-magnetic field associated with the flow of current in a low-pressure discharge (mercury vapour at less than 2×10^{-2} mm. pressure) plays an important part in determining the radial density distribution at currents as low as 30 amp. The effect of this magnetic field can be treated by adding a 'magnetic potential' term $V_m = \int_0^r \bar{w}_1 H dr$ to the electrostatic potential V_s in the Boltzmann equation, $\bar{w}_1$ being the longitudinal electron-drift velocity. The drift of electrons and ions to the tube walls is equalized at low arc currents by a radial electric field. Since the self-magnetic field tends to reduce the drift of electrons to the walls while having a negligible influence on the positive ions, increasing the arc current leads to a progressive reduction in the radial electric field.

Probe measurements in a mercury-vapour arc tube (diameter 54 mm.) at pressures less than 10^{-3} mm. show that at currents greater than 50 amp. the radial electric field E_s is negligible compared to the term $\bar{w}_1 H$ except close to the tube walls. With the assumption that E_s may be neglected, the three equations yielding the electron density distribution are:

$$n_1 = n_{10} \exp\left[\frac{-e_1 V_m}{kT_1}\right] \quad (1)$$

$$V_m = \int_0^r \bar{w}_1 H dr, \quad (2)$$

$$H = \frac{2J}{r} = \frac{4\pi}{r} \int_0^r n_1 e_1 \bar{w}_1 r dr. \quad (3)$$

The solution found is:

$$\frac{n_1}{n_{10}} = \left[\frac{1}{1 + A\frac{r^2}{r_0^2}}\right]^2 \quad (4)$$

where $A = \frac{\frac{1}{2}J_a e_1 \bar{w}_1}{kT_1 - \frac{1}{2}J_a e_1 \bar{w}_1}$,

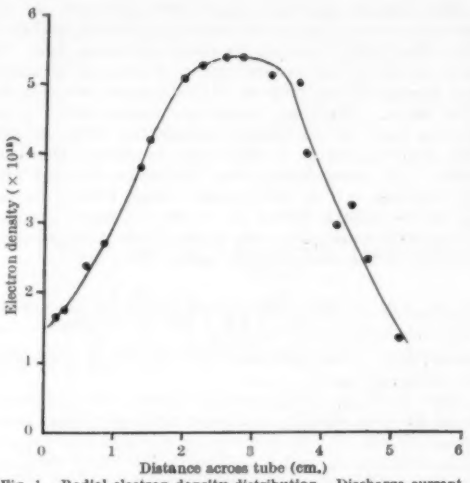

Fig. 1. Radial electron density distribution. Discharge current, 150 amp.; mercury vapour pressure corresponding to 19·5° C.; $\bar{w}_1 = 1{\cdot}5 \times 10^7$ cm./sec.; electron temperature, 31,500° K.

In practical units, $A = \dfrac{J_a \bar{w}_1}{2 \times 10^9 V_1 - J_a \bar{w}_1}$, (5)

where J_a is the arc current in amp., $\bar{w}_1$ is in cm./sec., V_1 in volts, r in cm. and $V_1 = kT_1/e_1$.

The axial electron density is given by:

$$n_{10} = \frac{1{\cdot}99 \times 10^{18} J_a}{\bar{w}_1 r_0^2 \left(1 - 5 \times 10^{-10} \dfrac{J_a \bar{w}_1}{V_1}\right)}. \quad (6)$$

It is interesting to note that as $J_a \bar{w}_1 \to 2 \times 10^9 V_1$, $n_{10} \to \infty$, suggesting that the arc tends to contract into a narrow channel. This behaviour may be compared with that termed by Tonks[1] the 'pinch effect'. Fig. 1 illustrates the electron-density as a function of tube radius under conditions where the arc is beginning to constrict. If the discharge is to remain stable, this tendency must change in the neighbourhood of the critical current. At sufficiently high currents the degree of ionization becomes appreciable, and both $\bar{w}_1$ and V_1 tend to increase with current; thus it is not possible to decide whether instability occurs without a more detailed analysis.

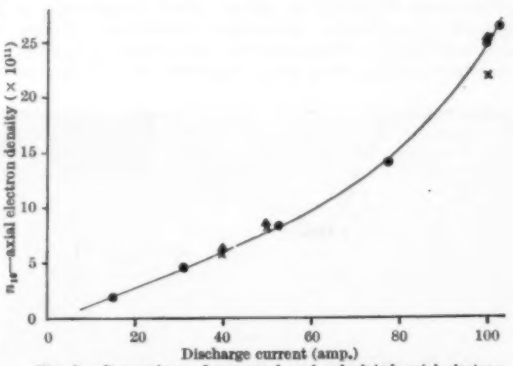

Fig. 2. Comparison of measured and calculated axial electron densities: ●—●—, density from probe measurements; ▲—▲—, density computed from eq. (7); ×—×—, density computed from eq. (6). Mercury vapour pressure corresponding to 10° C.

The results quoted above are derived on the assumption that the electrons are in strict equilibrium with the fields, that is, no radial electron flow. In fact, there is always a generation of ions and electrons and a constant radial flow of momentum towards the tube walls. The ions, which are responsible for the greater part of the radial momentum flow, acquire this predominantly in the ion sheath at the tube walls. By considering the discharge divided into two regions—(1) in the plasma where $H\bar{w}_1 > E_z$ and (2) in the sheath where $E_z > H\bar{w}_1$—a correction can be applied to equation (6) to give the axial electron density in the steady-state case. This is:

$$n_{10} = 3{\cdot}21 \times 10^{11} \frac{I_{2w}}{V_1^{1/2}} \left[\frac{2 \times 10^9 V_1}{2 \times 10^9 V_1 - J_a \bar{w}_1}\right]^{\frac{1}{2}}, \quad (7)$$

where I_{2w} is the positive ion current to the walls in milliamp./cm.^{2}.

Fig. 2 shows a comparison between the measured axial electron density and that computed from equations (6) and (7). At the higher currents the relationship between J_a and n_{10} departs markedly from the linear one found at low currents.

It might be expected that at still greater currents the axis of the arc could become negative with respect to the surrounding plasma. This reversal would be too small to influence appreciably the radial-density distribution unless the ions gain energies comparable with the electron energies. The life of a positive ion is generally too short to acquire any appreciable energy by electron-ion collisions or by collisions of the second kind.

It is believed that the assumption $E_z = 0$ is justifiable over a wide range of currents, and in this range the self-magnetic field is the most important factor determining the electron density.

A detailed report of this work is to be published shortly.

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W. T. Cowhig

Clarendon Laboratory,
Oxford.

[1] Tonks, L., *Phys. Rev.*, **56**, 360 (1939).

Grain Boundaries and Sintering

In the course of a study of thermal etching, some experiments were carried out on specimens cut from cold-rolled, high-purity silver sheet containing a number of uniformly distributed blow-holes. A flat, electrolytically polished surface was prepared on each specimen, which was then annealed for 19 hr. at 900° C. in oxygen-free nitrogen. Fig. 1 shows the appearance of a section through a specimen which has been subject to this treatment. The grain boundaries have been revealed in the section by thermal etching.

It was noticed that in the annealed specimens most of the blow-holes lay in the planes of the grain boundaries, and it was also apparent that the large number of small blow-holes in the original material had been replaced by a smaller number of larger holes of nearly uniform size. It seemed that, as grain growth was taking place after the initial recrystallization, the grain boundaries moving through the material swept up all the blow-holes in their path, the holes afterwards migrating with the boundaries.

The increase in size of the blow-holes can easily be explained in terms of the free energy of the system. If two small blow-holes unite to produce one large hole, the total surface area, and hence the total free energy of the system, decreases. Similarly, when a bubble passes from the interior of the grain to a grain boundary, an area of grain boundary corresponding to the cross-section of the bubble is destroyed. Since the surface area of the bubble remains constant, free energy corresponding to the area of boundary destroyed is liberated when the boundary meets the bubble. Similarly, free energy is required to move the boundary away from the bubble. The bubble is thus likely to move with the advancing boundary. But, as can be seen from Fig. 1, some of the bubbles must have moved a considerable distance with the grain boundaries. Some mechanism must be moving material from one side of the bubble to the other at quite a high rate. It seems possible that surface migration is responsible for this. A difference in free energy, such as a difference in strain energy, between the two crystals forming the grain boundary would then also provide a driving force to move the bubbles.

In studies of the elimination of isolated pores from a solid body—the second stage of sintering—it is usual to consider that the pores are uniformly distributed throughout the body (see, for example, Mackenzie and Shuttleworth[1]). In view of the observations recorded here, this assumption does not seem to be generally justified, and its use may be misleading. A plastic flow mechanism, for example, would cause a much more rapid increase in density of a body containing pores distributed in planes than of a second body containing the same pores randomly distributed.

The initially flat, polished surface of the sheet containing blow-holes would frequently show large grooves, sometimes associated with steps, after the first annealing process. Fig. 2 shows such a step. The annealed specimen has been plated with copper, and then a section taken normal to the prepared surface. These grooves are much larger than those formed on heating a specimen free from blow-holes under the same conditions. It is difficult to see how these features could develop without the transference of holes from the outer layers of the metal to the surface itself. This could take place if a grain boundary associated with holes were moving into the surface

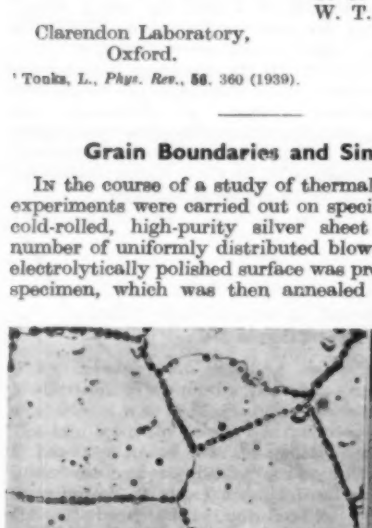


Fig. 1. Section through annealed surface (× 75)

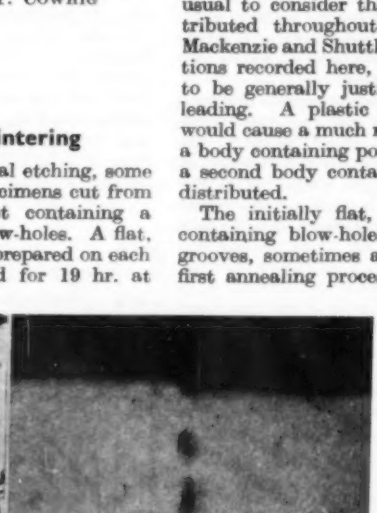


Fig. 2. Step in annealed surface (× 250)

of the specimen, or if the holes could move towards the surface in the plane of the grain boundary either bodily or as vacant lattice sites. Such processes would lead to the increase in density of the surface layers of the specimen if the final grain size were small compared with the size of the specimen.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this note.

A. P. GREENOUGH

Royal Aircraft Establishment,
Farnborough, Hants.
July 6.

[1] Mackenzie, J. K., and Shuttleworth, R., *Proc. Phys. Soc.* **62B**, 833 (1949).

Viscosity of Liquids at High Rates of Shear

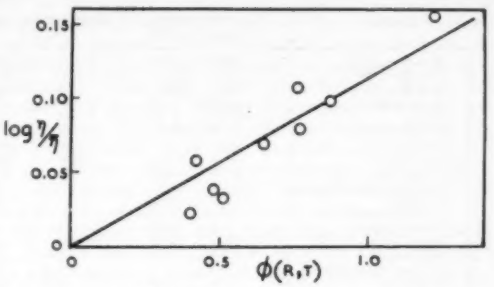
WHILE it is well established that solutions of macro-molecular substances may show an anomalous fall in the coefficient of viscosity at high rates of shear, there is much conflict in the experimental evidence relating to the behaviour in this respect of ordinary lubricating oils. It was suggested by Grunberg and Nissan[1] that at high rates of shear the viscosity of ordinarily 'Newtonian' liquids might become a function of the rate of shear. They developed an equation to account theoretically for this dependence, and calculated that for *n*-pentane at 30° C. the viscosity should fall sharply over a range of the rate of shear from about 10^8 to 10^{11} sec.$^{-1}$.

In experimental measurements it is difficult to keep the temperature constant, since at high rates of shear a considerable amount of heat is developed. Under these conditions, the effect of a rise in temperature is twofold. There is the normal decrease in viscosity found with all liquids, and in addition the extent of the anomaly in viscosity caused by the high rate of shear is less at high temperatures. This latter effect of temperature may be estimated from the equation of Grunberg and Nissan. It is now possible to test their theory with some measurements (with a high-speed rotational viscometer) of the viscosity at high rates of shear of a mineral oil which conformed to the S.A.E.30 specification (to be published in full elsewhere). It was found that the anomalous fall in viscosity increased with the rate of shear (for values up to about 2×10^6 sec.$^{-1}$); but a rise in temperature produced a very marked decrease in the anomalous fall in viscosity.

The extent of the anomaly may be represented by the ratio $(\eta/\bar{\eta})$ of the normal viscosity to the viscosity, at the same temperature, for the high rate of shear. For the present experimental conditions the theory of Grunberg and Nissan predicts very nearly a linear relationship between log $\eta/\bar{\eta}$ and

$$\frac{R\eta}{T^2} \cdot \frac{1}{1 + R\eta/1{\cdot}103 \times 10^4 T} = \varphi(R,T)$$

where R is the rate of shear (sec.$^{-1}$) and T is the absolute temperature. The experimental results are plotted in this way (see graph). It is seen that there is reasonable agreement with the theory, considering that the points correspond to a very wide range of experimental conditions. Although there



is some scatter about the straight line, the correlation coefficient between log $\eta/\bar{\eta}$ and $\varphi(R,T)$ has the high value of 0·85, which is significant at the probability level of 0·002.

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Viscosity-Temperature Dependence

THE relationship between η, the viscosity of a liquid at a temperature T, and E_v, the activation energy of viscous flow, has been expressed by

$$\eta = A \exp E_v/RT \qquad (1)$$

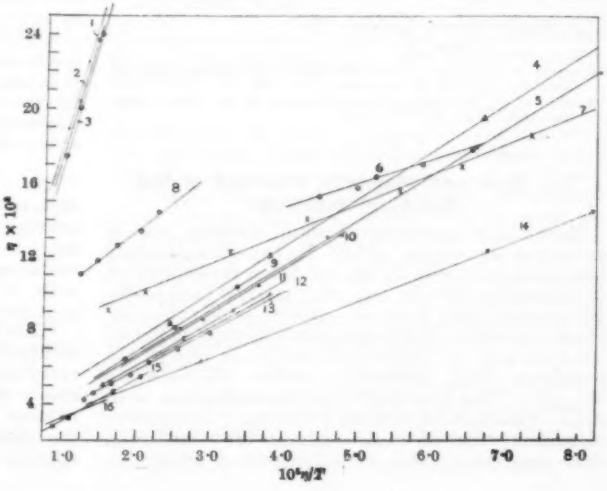
$$\text{or log } \eta = E_v/RT + \text{constant.} \qquad (1a)$$

Equation 1*a* implies that a linear relationship exists between log η and $1/T$. In many cases investigated, however, the straight lines obtained when log η is plotted against $1/T$ are parts of curves extending over wide ranges of temperature.

In the case of petroleum oils, the A.S.T.M. chart, or an equation of the form,

$$\text{loglog } (\nu + c) = A_1 \log T + B,$$

where ν is in centistokes, is extensively used; but convex and concave deviations from the implied



Liquid	Viscosity range (η poises × 10^3)	Temperature range (° C.)	$\frac{\eta}{T}$ (10^4) range
1. 96·5 Fe : 3·5 C	29·0 to 17·5	1,250 to 1,400	1·9 to 1·0
2. 97·0 Fe : 3·0 C	28·0 ,, 20·3	1,300 ,, 1,400	1·8 ,, 1·2
3. 97·5 Fe : 2·5 C	26·5 ,, 22·5	1,350 ,, 1,400	1·6 ,, 1·3
4. Formic acid	23·9 ,, 5·58	7·6 ,, 97·2	8·5 ,, 1·5
5. Water	26·0 ,, 2·83	− 10 ,, 70	9·9 ,, 1·2
6. Ethyl alcohol	17·9 ,, 15·4	0 ,, 70	6·6 ,, 4·5
7. Mercury	18·6 ,, 9·3	− 20 ,, 300	7·3 ,, 1·6
8. Cadmium	14·4 ,, 11·0	349 ,, 603	2·3 ,, 1·3
9. Acetic acid	10·3 ,, 4·4	30 ,, 103	3·4 ,, 1·2
10. Carbon tetrachloride	13·3 ,, 5·0	0·6 ,, 74	4·8 ,, 1·5
11. Benzene	9·0 ,, 3·5	0 ,, 70	3·3 ,, 1·0
12. Methyl alcohol	8·1 ,, 3·5	0 ,, 60	3·0 ,, 1·0
13. Chloroform	7·9 ,, 4·2	− 10 ,, 50	3·0 ,, 1·3
14. Ethyl ether	25·7 ,, 1·9	− 110 ,, 40	15·7 ,, 0·6
15. *n*-Heptane	4·8 ,, 2·1	6·4 ,, 92·2	1·7 ,, 0·6
16. Carbon disulphide	4·3 ,, 3·1	0·4 ,, 45·9	1·6 ,, 0·9
17 *p*-Xylene	7·5 ,, 2·3	8·3 ,, 135·2	2·8 ,, 0·6
	Poises		(η/T)
18. *Synthetic oils	29,310 to 38·5	− 30 to 61	120 to 0·1
19. *Baku bitumens	21,210 ,, 25·5	40·0 ,, 100	67·6 ,, 0·07
20. *Molasses	109·7 ,, 5·4	70 ,, 120	0·3 ,, 0·01

* Not shown in the diagram.

straight line appear, particularly at low temperatures[1], and in the case of the polyglycols, polymethylsiloxanes, halocarbons and 'Ucon' fluids[2]. These deviations have been variously explained at low temperatures by thixotropy, and at high temperatures by thermal agitation, loss of hydrated water, and statistical uncoiling of long-chain molecules. While such effects may occur, some of the explanations appear speculative.

It cannot be concluded that existing methods of representing viscosity temperature data are entirely satisfactory, particularly over the extended ranges of temperatures modern usage encounters.

From the form of the viscosity-temperature curve of a liquid it was suspected that a simple equation would apply, of the type

$$\eta\,(1 - a/T) = b \qquad (2)$$

$$\text{or } \eta = a\eta/T + b, \qquad (2a)$$

where η is in poises ; a and b are constants.

Equation 2*a* has been investigated for the miscellaneous liquids given in the accompanying table. In the graph, η has been plotted against η/T and, as may be seen, the linear relationship holds over the temperature-ranges recorded. In the region of the boiling points, deviations appeared ; but not at low temperatures, where thixotropic effects have been reported.

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The Spin and Magnetic Moment of the Rhodium Nucleus

Naturally occurring rhodium consists almost entirely of one isotope, $_{45}Rh^{103}$. No hyperfine structure has previously been found, nor has a determination of the nuclear spin by any other method been made. By passing light from a hollow-cathode tube containing rhodium through an atomic beam of rhodium, we were able to observe absorption in one of the resonance lines, 3434·90 A. ($4d^85s\ {}^4F_{9/2} - 4d^85p\ {}^4G_{11/2}$)[1]. The absorption spectrum shows a well-resolved doublet, of splitting 0·023 cm.$^{-1}$. This proves conclusively that the nuclear spin has the value $I = \frac{1}{2}$, since any other value would produce a quartet or higher multiplet. The splitting of the line must be attributed to the ground-term, which contains an unpaired *s*-electron. If perfect Russell–Saunders coupling is assumed, the value of the magnetic moment can be calculated by means of the conventional approximation methods. It is found to be − 0·11 nuclear magnetons. This is one of the smallest magnetic moments so far reported.

The negative sign is not quite certain. It is derived from the observation that the component of shorter wave-length appears to be the stronger. We are attempting to confirm this by further experiments.

From the theory of shell structure, Goeppert Mayer[2] predicts a spin of either $\frac{1}{2}$ or 9/2 for the rhodium nucleus. Feenberg and Hammack[3] expect a spin of 7/2 or 9/2, arising from the configuration $(5g)^{2n+1}$, for the ground-state, and a spin of $\frac{1}{2}$, arising from the configuration $(5g)^{2n}(2s)^1$, for the metastable state. Since, according to our experiments, the ground-term has the spin $\frac{1}{2}$, the latter assignments of configurations should be interchanged.

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Distribution of Range-finding Errors

The optical range-finder measures range by what is ultimately a visual estimation of the angle subtended by its base at the target. Thus

$$R = \frac{b}{\theta}, \quad \delta R \simeq -\frac{R^2}{b}\delta\theta. \qquad (1)$$

Consequently, for a given type of instrument the customary measure of error used is $\delta R/R^2$. This will be approximately proportional to $\delta\theta$ and can be used for combining or comparing errors of measurements on targets at different ranges.

In some recent trials a considerable number of estimates of ranges to targets at accurately surveyed distances was made. The frequency distribution of errors expressed in the form

$$y = \text{range error}/(\text{true range})^2$$

departed significantly from the normal form. More unexpectedly, it showed significant skewness, there being a marked excess of large positive errors. The accompanying table compares observed percentages with those expected on the basis of a normal distribution.

While the distribution of errors in visual measurements of angle is probably far from normal, there is every reason to expect it to be symmetrical. The reason for the skewness observed lies in the approximation used in (1). This approximation implies that range errors of equal magnitude will result from angular errors of the same size but of opposite signs.

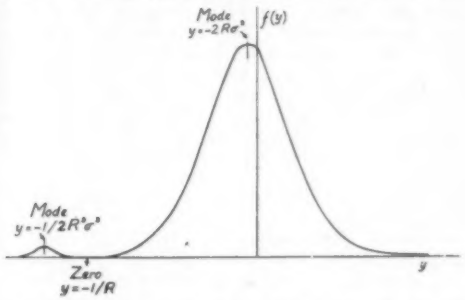
Size of zone	± 19 units	± 46 units	± 72 units
% inside zone on normal theory	50 per cent	90 per cent	99 per cent
% of observations inside	57 ,,	89 ,,	96 ,,
% of observations outside (above)	22 ,,	7 ,,	3 ,,
% of observations outside (below)	21 ,,	4 ,,	1 ,,

In fact, the positive change in range due to replacing θ by $(\theta - \varepsilon)$ is greater numerically than that due to using $(\theta + \varepsilon)$.

Assuming a normal distribution of angular errors of standard deviation $b\sigma$, the frequency function of the measure of error y will be:

$$\frac{1}{\sqrt{2\pi}\,\sigma\,(1 + Ry)^2} \cdot \exp\left[\frac{-y^2}{2\cdot^2(1 + Ry)^2}\right].$$

The general behaviour of this function is illustrated by the accompanying graph, which is not to scale.



The approximation used in (1) is equivalent to disregarding the term Ry at the appropriate places. In the practical application R was of the order 10^2 and σ of the order 10^{-2}. Consequently, values of $|Ry|$ greater than 0·03 will scarcely ever arise. For small $R\sigma$, the proportions of readings outside the limits $\pm k\sigma$ will be

$$\int_k^\infty \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-x^2}{2}\right) dx \pm \frac{Rck^2}{\sqrt{2\pi}} \exp\left(-\frac{k^2}{2}\right).$$

In order to check the above explanation the errors were expressed in the form:

range error/true range × observed range.

This expression is exactly proportional to the angular error, and the resulting distribution was found to be symmetrical, though still not normal.

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Static Meson Potentials and the Deuteron Problem

The static potential of interaction between two nucleons predicted by meson theory[1] has the general form

$$\left(J + F\mathcal{D}\, r\, \frac{d}{dr}\, \frac{1}{r}\, \frac{d}{dr}\right) \varphi(r);$$

$\varphi(r)$ is here the Yukawa central potential; $\mathcal{D}$ the dipole axial operator; J and F two constants depending on the source parameters. The r^{-3} singularity of this potential must be removed by some arbitrary cut-off procedure. We have investigated the ground-state solution of the deuteron equations for such a potential, using the 'zero cut-off' introduced by Bethe[2], for the two values 225 m and 284 m of the meson mass, and a number of numerical values of the constants J and F. In each case the value 2·24 MeV. of the binding energy of the deuteron was assumed, and the amount P of D-state, the quadrupole moment Q and the cut-off radius r_c were determined.

It is found that the best experimental values $P_0 = 0{\cdot}04$ and $Q_0 = 2{\cdot}73 \times 10^{-27}$ cm.^{2} are obtained for the following values of the potential constants:

For the mass 225:

$$J = 28 \text{ MeV.}; \quad F = 14 \text{ MeV.} = \tfrac{1}{2}J; \quad r_c = \tfrac{1}{2}r_0;$$

For the mass 284:

$$J = 53 \text{ MeV.}; \quad F = 35 \text{ MeV.} = \tfrac{2}{3}J; \quad r_c = \tfrac{1}{4}r_0;$$

where r_0 is the range of the nuclear forces. Thus, the ratios F/J and r_c/r_0 are comparable and both increase with the meson mass; the magnitude of the former shows that the axial dipole coupling is 'large'. Further, the sign of J indicates that the central potential gives rise to an attraction in the ground-state.

The calculations made with several other pairs (J,F) give us an idea of the relations between these constants and the values of P, Q and r_c. For example, we find that:

(1) For $Q = Q_0$, P increases with decreasing J; in particular, a repulsive potential would clearly give too high an amount of D-state.

(2) For the right value of F, the value of Q is practically independent of J or P, when

$$3 \text{ per cent} \leqslant P \leqslant 5 \text{ per cent.}$$

(3) For the right value of J, the ratio Q/P is practically independent of F, when

$$0 \leqslant P \leqslant 5 \text{ per cent.}$$

These last two properties hold more accurately for the mass 284 than for the mass 225.

On the other hand, for the meson mass 284, one finds[3] for the value $^3J^{(0)}$ of J for a purely central meson potential ($F = 0$)

$$^3J^{(0)} = 53{\cdot}2 \text{ MeV.},$$

which is surprisingly near the corresponding value of J for the non-central potential. This means that the large axial dipole coupling has only a very small effect on the binding energy. The value $^1J^{(0)}$ of J in the singlet S-state is[4]

$$^1J^{(0)} = 34{\cdot}9 \text{ MeV.}$$

The fact that this value is equal to that of F is probably fortuitous. These numerical coincidences occur only for mass values about 284.

A further discussion shows that it is not possible to get the right pair (J,F) with any theory involving only one kind of meson field. Thus we have to adopt a mixture of fields; for example, a mixture of pseudoscalar and vector fields[5]. (Our method does not allow us to choose a theory with fields of different masses.) For the mass 284, the pseudoscalar-vector theory leads to the following equations for the source parameters:

$$\text{vector field} \begin{cases} g_1^2 - \mu g_1 g_2 = 0{\cdot}031\ \hbar c = 4{\cdot}2\, e^2, \\ g_2^2 - \mu g_1 g_2 = 0{\cdot}064\ \hbar c = 8{\cdot}8\, e^2, \end{cases}$$

$$\text{pseudoscalar field}: f_2^2 + \mu f_1 f_2 = 0{\cdot}144\ \hbar c = 19{\cdot}7\, e^2;$$

μ is the ratio of the meson to the proton mass.

The first of these two biquadratic systems has two pairs of solutions:

$$\text{for } g_1g_2 \text{ positive} \begin{cases} g_1^2 = 0{\cdot}039\ hc = 5{\cdot}3\ e^2 \\ g_2^2 = 0{\cdot}072\ hc = 9{\cdot}9\ e^2 \end{cases}$$

$$\text{for } g_1g_2 \text{ negative} \begin{cases} g_1^2 = 0{\cdot}025\ hc = 3{\cdot}4\ e^2 \\ g_2^2 = 0{\cdot}058\ hc = 7{\cdot}9\ e^2. \end{cases}$$

I am indebted to Prof. L. Rosenfeld for a stimulating correspondence and fruitful discussions.

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Acarine Growth: a New Ecdysial Mechanism

THE cyclic growth and metamorphosis of members of the Acarina have been neglected as a field for embryological research, the primary reason probably being the difficulty of devising rearing arrangements which would provide individuals at known phases of growth and development; moreover, the minute size of most of these animals, and the relatively large surface area of strongly sclerotized cuticle, have probably been responsible for abortive attempts to make the required histological investigations.

The essential stages of acarine growth are the hexapod larva, the nymph and the adult, with interposed transition stages which may conveniently be termed the pre-nymph and the pre-adult. There are deviations from the normal course; for example, the Tyroglyphid mite has two nymphal instars with usually the spasmodic production of the peculiar hypopus between them; the Oribatid mite has three nymphal instars; and the Trombiculid mite (harvest mite) has one only. Furthermore, the differences in development within the Acarina are as interesting as those we associate with hemi- and holo-metabolous insects.

The Tyroglyphid and Oribatid mites during the early developmental phase cast the old cuticle as a prelude to the retraction of the epidermis, and the new individual develops within the cast cuticle of the preceding stage. The growth and development of the harvest mite, *Trombicula autumnalis*, are more complex. The old cuticle is cast; but when the contained organism has reached the stage of having produced well-developed appendages, the newly formed cuticle is cast, so that the developing organism is now enclosed by the outer cuticle of the previous stage and a second or intermediate cuticle. This intermediate cuticle is thin; it is homologous with the "apoderma" of Henking[1], and the "Zwischenhaut" of Claparède[2], and corresponds to the deutoval membrane of the egg. The transition stages of the harvest mite therefore closely resemble the insect pupa while those of the Tyroglyphid and Oribatid mites are accompanied by a typical ecdysis. In fact, it would be possible to classify mites according to the type of development; the presence or absence of puparium

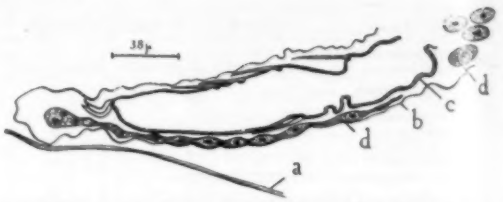

Fig. 1. Section of the pre-nymphal stage of *T. autumnalis*. *a*, larval cuticle; *b*, intermediate cuticle; *c*, nymphal cuticle; *d*, intermediate cells

formation during post-embryonic growth distinguishing the two basic groups.

When the insect cuticle is cast it separates cleanly from the epidermis. For at least those members of the Acarina which I have investigated, this ecdysial mechanism does not hold. The epidermis in the case of the harvest mite and the Oribatid mite first dedifferentiates, and most of the basophil nuclei and ejected chromatin material are arranged along the inner region; but the outer region is transformed into a distinct layer of flattened cells, each with a single nucleus and non-granular acidophil cytoplasm (Figs. 2*A* and *B*). Of the two layers of the epidermis the outer one, still more or less attached to the cuticle, separates from the inner layer, which retracts before eventually laying down the new cuticle. The intermediate cells of *T. autumnalis*, which lie between the two cuticles (Fig. 1), are homologous with the isolated cells noted in *Trombidium fuliginosum* by Henking[1], and the "hæmamœbæ" of *Atax bonzi* observed by Claparède[2]. Both these authors failed to understand the significance of the cells, and their indefinite speculations with respect to the origin and function of these cells have only led to confusion.

When the cuticle is cast, the endocuticle first undergoes dissolution, and it is significant that intact intermediate cells are still contiguous with the undigested exuvium and they even migrate very slightly into it; but whereas the cytoplasm of these cells is uniform when they are first cast off, it becomes intensely vacuolated after the marked dissolution of the cuticle, which further suggests that these intermediate cells are associated with the dissolution of the cast cuticle (Fig. 2*B*).

In view of the nature of this ecdysial mechanism, described above, it is interesting to note that in the decapod crustacea, Yonge[3] observed nuclei in the

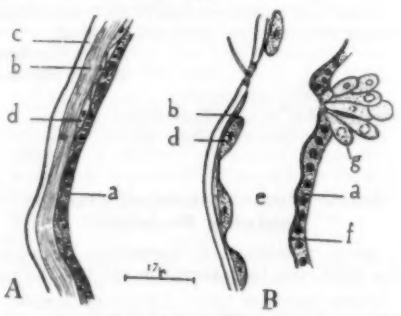

Fig. 2. Sections of pre-adult transition stages of an Oribatid mite. *A*, Early differentiating phase showing the epidermal split; *B*, late differentiating phase showing the cast cuticle with the intermediate cells adhering to it: *a*, epidermis; *b*, endocuticle; *c*, sclerotized exocuticle; *d*, intermediate cells; *e*, exuvial cavity; *f*, newly secreted adult cuticle; *g*, dermal gland cell

exuvial cavity during the casting of the old cuticle of the œsophagus of *Homarus*; although he was unable either to distinguish the cytoplasmic components of these nuclei, or to discover their origin, he suggested they played a part in softening the 'chitin' (endocuticle) of the exuvium. Browning[4], who investigated the moulting process of the spider, *Tegenaria atrica*, came to the conclusion that the cells found in the exuvial cavity were discarded 'granulocytes', which had functioned at the previous moult in laying down the new 'exocuticula', and his findings give no reason to suppose that the ecdysial mechanism of spiders is similar to that of the closely related mites.

A former suggestion that certain glands in insects secrete the chitinase and protease in the moulting fluid[5] has given way to doubt, since they are now thought to be concerned with the production of the cement layer of the epicuticle[6]. In the mites I have studied there has been no evidence of the presence of 'moulting glands', and since the intermediate cells, of epidermal origin, are associated with the dissolution of the cuticle, it is legitimate to conclude that the process in mites is more in line with the view that the enzymes are secreted by the general epidermis. Occasionally, the intermediate cells lie, without apparent effect, upon the newly formed cuticle, and since in the harvest mite even the epicuticular exuvium appears to be soluble in the secretion produced prior to emergence, I am inclined to the view that resistance of cuticle to dissolution depends upon its viability rather than upon the mechanical protection of an epicuticle.

This ecdysial mechanism, which so far as can be found is an original observation for mites, is one of many characteristic features of histological differentiation associated with acarine growth, the morphogenetic mechanisms of which I have been investigating for the past few years, and the results of which I hope to publish elsewhere.

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July 4.

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Protection against Aphids by Seed Treatment

In 1948, Schrader[1] reported the discovery by himself and Kükenthal of the systemic insecticidal properties of *bis*(*bis*dimethylamino phosphonous) anhydride. $[(CH_3)_2N]_3PO.O.PO[(CH_3)_2N]_2$. Since then a number of papers on the biological activity of this substance has been published, the most comprehensive from the practical control angle being the one by Ripper *et al.*[2] giving full results of field trials against hop aphids.

The present communication describes results obtained with a new technique of protecting certain plants from aphid attack. By soaking the seeds in an aqueous solution of *bis*(*bis*dimethylamino phosphonous) anhydride the establishment of aphids and red spider on the plants grown from them is prevented for a considerable time (more than fifty days under the experimental conditions employed). The treatment is prophylactic rather than chemotherapeutic, the latter term being rightly applicable only to the cure of an attack by pest or disease after its establishment.

The treatment[3] is simple and economical in manpower and materials. It does not require elaborate apparatus and, at the level suggested, has no phytocidal effect. It may therefore have practical application in the control of aphids and other insects on suitable plants, provided the seed is large enough to allow for the absorption of sufficient of the active principle.

In a typical experiment, some broad bean seeds were weighed individually (average weight 2·57 gm.) and five seeds at a time soaked in an aqueous solution of *bis*(*bis*dimethylamino phosphonous) anhydride. The strength of the solution ranged from 0·016 to 0·5 per cent. After 24 hr., when the average increase in weight of the seeds was 108·5 per cent, the seeds were re-weighed and each planted in a new earthenware pot containing about 300 gm. of soil. Chemical analysis of the remaining solution showed that the phosphorus content had increased by amounts varying from 25 to 50 per cent, suggesting that the seed does not take up the active principle in the same proportions as water. At the intervals after germination stated in the table, 50–100 *Macrosiphum pisi* (Kalt.) of all stages were shaken on each plant, which was then enclosed in a cheese-cloth bag. Mortality counts were taken after 24 hr.

Active principle in soaking solution (per cent)	% aphids dead . . . days after germination							
	9	14	22	26	36	43	53	60
0·5	100	99	97	93	85	30	27	17
0·128	99	94	39	56	33	7	17	5
0·064	95	63	34	31	22	5	18	—
0·032	77	9	12	13	25	3	7	—
0·016	15	5	10	7	4	2	5	—
Control	1	1	2	1	2	2	2	2

Even at the highest strength, after 53 days the mortality 24 hr. after re-infestation was low (27 per cent); however, it increased to 73 per cent within 72 hr. Thus, soaking the seed with a 0·5 per cent solution of the chemical gave protection to the plant for more than fifty days. After the sixtieth day, toxicity was almost lost. In other experiments, the seeds were allowed to dry after soaking; they retained their insecticidal properties at subsequent planting. Soaking with 1 per cent solution gave no phytotoxic effect; but 2 per cent gave a significant decrease in the germination-rate and stunting of the plants which developed.

Some experiments with aphids confined on individual leaves showed that toxicity is first lost among the younger leaves at the top. The chemical is therefore not evenly distributed in the plant but tends to remain in those parts where it was originally translocated from the cotyledons. After the latter are used up, newly laid-down plant tissue will decrease in toxicity.

The accompanying photograph shows the results of an experiment with cotton under greenhouse conditions. Reading from left to right, the pots contain plants from seed soaked with 2·0, 1·0, 0·5 and 0 per cent *bis*(*bis*dimethylamino phosphonous) anhydride in water. The plants were seven weeks old when the photograph was taken, and during this period they were frequently infested with *Aphis rhamni* and *Tetranychus* sp.

Experiments with a number of other plants and aphids indicate that, as a general rule, the protecting effect varies with the weight of the seed. Good results were obtained with cotton, pea, various beans and nasturtium, which were successfully protected against attacks by aphids and red spider. In some cases a slight stimulating effect on growth has been observed, suggesting utilization of phosphorus by the plant; but soaking at higher strength usually inhibited growth. This inhibiting effect was observed with most plants when the soaking strength was 2 per cent, but nasturtium seeds can tolerate at least 5 per cent without any ill-effect. Small-scale field experiments with peas and beans are at present in progress.

This work was carried out while I was working in Great Britain as a research fellow of Imperial Chemical Industries (China), Ltd. The hospitality of the Imperial Chemical Industries Laboratories at Hawthorndale and the advice and criticism given by members of the laboratory staff are gratefully acknowledged. Thanks are also due to Imperial Chemical Industries, Ltd., for permission to publish this work, a fuller account of which will appear elsewhere.

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Single-Pod Fermentation of Cacao

MANY aspects of cacao research require assessment of quality of the crop produced by experimental trees, and, as it is obviously desirable that such examination should be made as early as possible in the productive life of the tree, only extremely small samples, often the contents of one or two pods at most, are usually available for examination.

This communication describes a method for the fermentation of the contents of single cacao pods, which has produced very encouraging preliminary results. The method is based on a suggestion of the Cocoa Research Sub-Committee of the Colonial Office.

The apparatus consists of a 10-cm. Büchner funnel, covered with a half Petri dish with a central hole carrying a thermometer. This funnel serves as a fermentation chamber and, in use, its vertical wall is lined with a strip of banana leaf which acts as a heat insulator. The stem of the funnel projects through a rubber stopper into a flask which acts as a receiver for the 'sweatings' resulting from fermentation. This flask in turn is connected to a controlled air supply, and the flask and funnel are contained in a thermostatically controlled electric oven.

A sample of selected healthy beans from one ripe West African Amelonado cacao pod is prepared for fermentation by mixing it with a 'starter', prepared by adding 2 gm. dextrose to 10 c.c. of pulp from a large batch of cacao which has been allowed to ferment for 24 hr. The sample is then transferred to the funnel, covered with two disks of banana leaf and the Petri dish, placed in the oven and the air supply connected.

During the period of fermentation, moist air is displaced into the bean mass at a rate of 2·5–3 litres per 24 hr. Oven temperatures are adjusted as follows:

0–24 hr.	37–38° C.
24–72 ,,	43–44° C.
72–86 ,,	47° C.
after 86 ,,	49° C.

At the end of each 24-hr. period, the beans are thoroughly mixed by hand to secure uniformity of fermentation. Such a procedure does not provide sufficient aeration in the absence of continuous air displacement in the oven. When the predetermined period of fermentation is completed, the beans are removed from the funnel, immediately pricked with a pin to prevent shrivelling during drying and dried in the sun for seven days.

This method has given consistent results, and 100 per cent of fully fermented beans, estimated on their appearance when cut in longitudinal section, can be produced at will.

An independent panel in Great Britain has conducted flavour assessments on beans fermented by this method for four, five and six days and has indicated that samples fermented for five days were the most satisfactory; those fermented for only four days were under-fermented, while those fermented for six days were tainted by a slight flavour of butyric acid.

My thanks are due to the Director of the West African Cacao Research Institute for permission to make this communication.

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July 19.

Intracerebral Inoculation of Mice: Fate of the Inoculum

IT has long been known that a virus may become widely disseminated following intracerebral inoculation into an experimental animal. Thus generalized spread has been found throughout the guinea pig fœtus after intracerebral inoculation of influenza virus[1], vaccinia, tubercle bacilli, and submaxillary gland disease virus[2]; and yellow fever virus has similarly been demonstrated in remote sites after inoculation of the mouse fœtus[3]. However, Schlesinger[4] observed that only 3–10 per cent of the inoculum could be demonstrated in the brains of mice one hour after inoculation, whether equine encephalomyelitis virus or bacteriophage was the test agent, and stated that he was unable to account for

this loss. In view of the common usage of intracerebral inoculation in small animals, it seemed desirable to pursue the matter further.

C.16 bacteriophage, active against a strain of *Sh. flexneri*, was employed as the tracer substance, and sufficient plaques, in duplicate, were counted to make the results accurate to within at least ± 50 per cent. Mice were anæsthetized with ether and chloroform, and inoculated by 25-gauge needle passed to a depth of about 3 mm. beneath the skull. Between 2 and 8 per cent of the inoculated phage was recoverable with the brain and associated meninges, removed less than 5 min. after inoculation (in confirmation of Schlesinger's result). Total recovery of the phage was obtained from a suspension of a whole mouse made in a Waring blendor, indicating that the whole inoculum was still detectable. That most of the inoculum had entered the blood-stream seemed likely, as blood taken from the great veins of the neck at various times between 5 and 60 sec. after inoculation contained about 15 per cent of the phage per millilitre. In one experiment, about 10 per cent of the inoculum was isolated from the whole head, 2·5 per cent being removed with the brain and 2·5 per cent being present in the subcutaneous tissues at the site of the injection; at the same time, about 2 per cent of the inoculum was present in the liver. In most experiments the volume inoculated was 0·03 ml.; however, volumes as small as 0·005 ml., delivered by a micrometer-screw syringe, were not associated with demonstrably less spill-over into the blood-stream. The degree of spill-over was confirmed using a mixture of phage and the *WS* strain of influenza virus, the latter being titrated by allantoic inoculation of 11-day chick embryos; the same fraction of each inoculated virus was found in a sample of blood taken 60 sec. after inoculation.

How much of the inoculum is in contact with nerve cells is doubtful. Much of that which can be removed with the brain is presumably associated with the cerebrospinal fluid and meninges, as was demonstrated by Schaeffer and Muckenfuss[5], who studied the fate of indian ink inoculated intracerebrally into monkeys. In summary, intracerebral inoculation of mice deposits only a small fraction of the inoculum into the brain, the remainder being rapidly distributed throughout the mouse via the circulation.

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Nature of the Lung Enzyme which inactivates Serum Vasoconstrictor

Rapport *et al.*[1] reported the presence of an enzyme, in extracts of beef and dog lung, which inactivates serum vasoconstrictor. In an attempt to characterize the nature of the enzyme, we have used their method to make active preparations from sheep lung and have examined them by biochemical, manometric and physiological means.

Such preparations are far from pure; they contain oxyhæmoglobin and several active enzymes. The addition of hydrogen peroxide shows the presence of large amounts of catalase. A red colour on the addition of pyrogallol and hydrogen peroxide, and a dark purple colour on the addition of catechol, dimethylamine hydrochloride and hydrogen peroxide, shows the presence of peroxidase. In Warburg manometers at 37° the preparation slowly takes up oxygen at a continuously decreasing rate which is unaffected by the addition of glucose, succinate, pyruvate, lactate, phenol, catechol, tyrosine, tryptophane or glycine. The oxygen uptake is increased slightly by lysine and ethanolamine, and very greatly by tryptamine, tyramine or adrenaline; but it is not affected by cadaverine, putrescine and histamine. These results indicate the presence of a monoamine oxidase and the absence of a diamine oxidase. Acetaldehyde is rapidly oxidized, benzaldehyde slowly oxidized, showing the presence of an aldehyde oxidase.

Curve 1 shows the oxygen uptake at *p*H 7·7 and 37° due to 1·5 ml. of an active precipitate suspended in an equal amount of *M*/15 phosphate buffer and made up to a final volume of 5 ml. with the buffer. In the presence of 1 ml. *M*/100 tryptamine the uptake (curve 2) is greatly increased for about 1½ hr., after which it runs parallel to curve 1 (see Fig. 1). Curve 3 is obtained by subtracting the values of curve 1 from curve 2. The oxygen uptake slightly exceeds two atoms per molecule of tryptamine, suggesting an oxidative deamination of tryptamine with oxidation of the resulting aldehyde and catalytic decomposition of the hydrogen peroxide formed[2]. During incubation, control solutions remain light red whereas those containing oxidizable amines become dirty brown and show the spectrum of methæmoglobin.

Tryptamine solutions incubated with the lung preparation in Warburg tubes for 2 hr. lose about seven-eighths of their activity on the rat uterus or the sheep carotid. Histamine solutions show little or no loss of activity on the guinea pig gut; the preparation itself may contain up to 0·1 μgm. per ml. of histamine. Every preparation which destroyed tryptamine also destroyed the activity of sheep serum on the carotid artery. After 2 hr. the vasoconstrictor activity varied from a quarter to less than an eighth of the original. Fig. 2 shows the responses of a sheep carotid artery to 0·5 ml. of serum (*A*) unincubated, (*B*) incubated with lung preparation for various periods, and (*C*) incubated without lung preparation for 2 hr. Over a

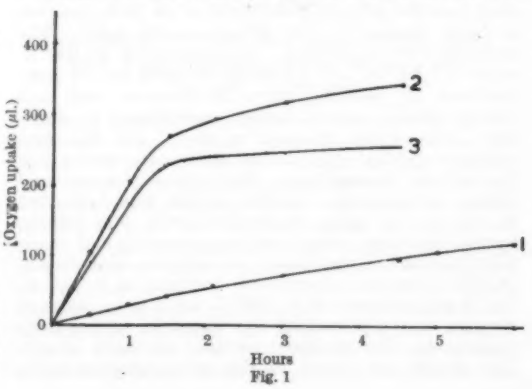

Fig. 1

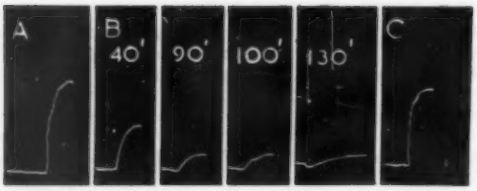

Fig. 2

few days the preparations lose their activity against monoamines, and as they do so they also lose their activity against serum vasoconstrictor.

These observations suggest that the serum vasoconstrictor contains a free terminal aliphatic amino-group which is oxidized by a monoamine oxidase in the lung preparation through the same mechanism as that suggested for tryptamine and tyramine.

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A New Method for Preparing Type-Specific Extracts from Hæmolytic Streptococci of Group A, Type 2

Hæmolytic streptococci of Lancefield's Group *A* (*Str. pyogenes*) can be classified into a number of types on the basis of precipitin reactions with an acid extract of the cocci and appropriate type-specific antisera; the type-specific material in the streptococci is a protein referred to as the *M*-substance[1]. It has been a general experience that it is frequently difficult to obtain active extracts from strains of some types, including Type 2. I have found that, if extraction is carried out at neutral *p*H, and at 120° C. (in an autoclave) instead of at 100° C., satisfactory extracts are obtained with strains of Type 2.

Four extraction methods were compared, using in each case the deposit from 30 ml. of an 18-hr. culture in broth containing 10^{-5} *M* iodo-acetic acid[2]. The methods were as follows: (1) Extraction at 100° C. with 0·3 ml. of *N*/5 hydrochloric acid for 10 min. followed by centrifuging, neutralization with *N*/5 sodium hydroxide and further centrifuging if necessary; this is the classical method. (2) The first method modified only in that the neutralization was carried out immediately after the extraction and before centrifuging. (3) The deposit was suspended in 0·5 ml. of saline, neutralized with *N*/5 sodium hydroxide using phenol red as indicator, and autoclaved at 120° C. for 5 min.; it was then centrifuged. (4) The same method as in (3) but heating to 100° C. for 10 min. instead of to 120° C. for 5 min. In each case the final supernatant was tested for type-specific antigen by the capillary method of Swift *et al.*[3]. The results are shown in the accompanying table.

Antigen obtained by method	Sera		
	Group specific	Type-specific	
		Type 2	Heterologous type
1	+++	0	0
2	+++	+	0
3	+++	+++	0
4	+++	+	0

The extract obtained by method (3) was clearly the best, and the fact that the reaction was lost when the extract was digested with trypsin for 24 hr. before testing indicates that it was most probably due to the *M* antigen. It is also noteworthy that neutralization before centrifuging gave a better extract than the classical method[1]; it is probable that the *M* antigen is precipitated at the acid *p*H, and in the case of method (1) is removed in the centrifuging.

The experiment described above has been repeated with six other strains of Group *A* streptococci, considered on the basis of agglutination typing to be Type 2, with the same results.

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Free and Combined Riboflavin in the Blood Serum of Œstrogenized Fowls

The serum riboflavin of the domestic fowl increases from an average of 0·07 p.p.m. to 0·86 p.p.m. when the bird comes into lay, and remains at this high level while laying; increases of the same order can be evoked by the administration of œstrogens to immature pullets[1].

Riboflavin has been shown to exist in the blood serum of rats in three forms: as free riboflavin, as flavin mononucleotide and as flavin adenine dinucleotide. In investigations into changes in serum riboflavin, it was therefore important to ascertain the relative concentrations of these three forms in both laying and non-laying pullets.

At this time, blood from œstrogenized immature pullets became available from other work in progress at this Centre, and this has been examined. The birds were Brown Leghorns bred at the Centre, and were ten weeks old at the start of the experiment. All birds were fed the same diet, and all received the injections on alternate days. They were killed on the day following the last injection, when they were twelve weeks old, and the bloods were examined by the method of Burch *et al.*[2] assuming all three forms to be present. The treatments and results are set out in the accompanying table.

Subsequent dissection indicated that increase in the dose of œstrogen had brought about hypertrophy

No. of bird	Dose of œstrodial benzoate (mgm.)	Free riboflavin (p.p.m.)	Flavin mono-nucleotide (p.p.m.)	Flavin adenine di-nucleotide (p.p.m.)
Y 1314	7 × 0·0	0·02	0·02	0·01
Y 1306	7 × 0·5	0·02	0·02	0·01
Y 1311	7 × 1·0	0·90	0·01	0·01
Y 1356	7 × 2·0	1·90	0·01	0·01
Y 1320	7 × 3·0	2·54	0·03	0·01

of the oviduct, and at the higher levels it resembled the fully active organ. On the other hand, in all cases the ovaries were quiescent, indicating that endogenous hormone production was negligible.

The results show that the increase in serum riboflavin evoked by the administration of α strogen consisted entirely of free riboflavin, and that the levels of combined riboflavin were not affected. They also indicate that changes in serum riboflavin can be followed by estimating the amount of vitamin present in trichloracetic acid filtrates of the serum, thereby greatly simplifying the analytical procedure.

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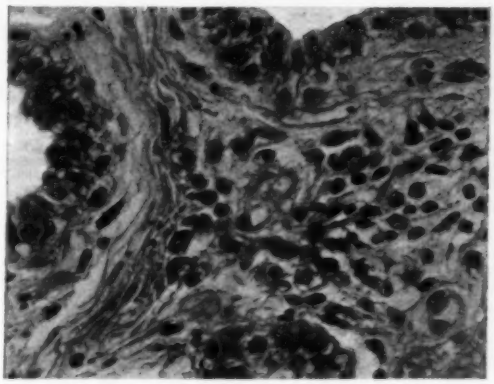
Plasmacytosis of the Bovine Udder during Colostrum Secretion and Experimental Cessation of Milking

The concomitance of bone marrow plasmacyte formation and induced hypersensitivity was noted by Kolouch[1] in 1938. This was succeeded by a large number of papers indicating the part played by the plasma cell in the secretion of specific antibodies and by clinical studies reporting the strict parallelism between hyperglobulinæmia and plasmacytosis in various diseases. These have been reviewed by Kolouch, Good and Campbell[2]. The present communication records that the plasmacytosis in the bovine udder is synchronous with heightened periods of immune-body formation at parturition and during experimental cessation of milking.

The concentration of immune bodies in the colostrum of cows has been investigated by Smith and Little[3], who showed that transmission of antibody from dam to calf was made through the colostrum milk, rather than by placental transmission as in the human. The chemical nature of these proteins has more recently been described by E. D. Smith. The great concentration of the immune globulin fraction of the colostrum—many times that of the maternal serum globulin—is noteworthy. Notwithstanding this fact, it has been thought that the source of the immune bodies is in the maternal blood-stream[4]. This work has been reviewed by Porter[5] and extended by the demonstration that experimentally the antibody content of milk may be caused to increase to the level of that in colostrum by cessation of milking for a week or more.

As the concept of the plasmacytic origin of specific antibodies demands that any such spectacular rise in immune globulin be accompanied by a properly timed wave of plasma cell formation, experiments were set up to make a rigorous test of the hypothesis. Three cows were used for the preliminary observations. Aseptic serial biopsies of the udder were performed with local anæsthesia in which several grams of secretory tissue were removed. These were fixed and sectioned according to usual techniques.

Biopsies of No. 278 (the cows used were from the herd of the Department of Dairy Husbandry, University of Minnesota), which was neither pregnant nor lactating, showed no plasma cells in the udder. Similar biopsies of No. 854 showed the abundance of plasma cells eight days prior to parturition. These were again found three days before calving, on the day the calf was dropped (see photograph) and four days later. A biopsy 18 days after calving revealed no plasma cells. In like manner, No. *E*607, late in a normal disease-free lactation, was biopsied and a very small number of plasma cells observed to be present. Milking was discontinued in two quarters of the udder, and four days later a large population of plasma cells was revealed in the biopsy. These were again noted eleven days after milking had ceased. Following this third biopsy, the two quarters were again milked regularly, and fifteen days later only a very small number of plasma cells were to be found.



Biopsy of mammary gland of cow 854 made on day of calving. Note plasma cells in connective tissue septa between alveoli. Cresyl Violet and Erythrosin stain

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July 8.

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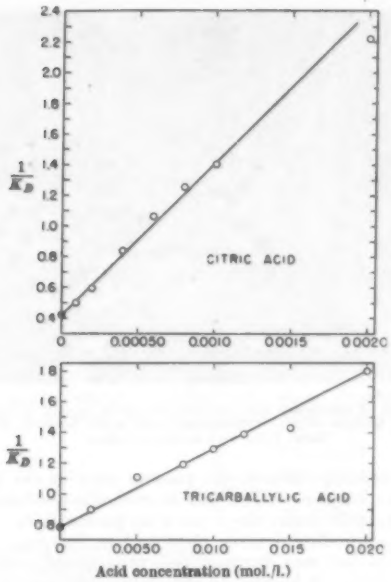
Complexes of Calcium with Citric Acid and Tricarballylic Acids measured by Ion Exchange

We are engaged in a study of the composition and stability of the complex ions which result from the interaction between metal ions and anions, particularly those of biological importance. The determinations are made by measuring the degree to which tracer levels ($\sim 10^{-8}$ *M*) of a radioactive cation are taken up by a synthetic organic cation exchanger in the presence of known concentrations of a complex ion-forming anion[1–3]. This ion-exchange procedure has several unique advantages[1]. For example, the dissociation constants of several different metal–organic acid complex ions can be measured simultaneously in the same solution, no corrections are



needed for the amount of anion utilized for the formation of the complex ion, and the effect of graded changes in the solutions of such factors as ionic strength, temperature, or dielectric constant can be studied on the same systems. Cation exchange resins such as 'Dowex 50'[4] (manufactured by the Dow Chemical Co., Midland, Mich.) are now used in our experiments because their capacity is independent of the *p*H.

This communication illustrates the application of the ion-exchange method by presenting the results of measurements made on the interaction of calcium ions with a pair of closely related acids, citric and tricarballylic. Citric and tricarballylic acids differ by the presence of a hydroxyl group in the former. The experiments are conducted at a *p*H of 7·2, so that the acids are completely dissociated.

The formulæ used for calculation of the dissociation constants are derivable from mass-action considerations[1]. In a recent paper on the complex compounds of radium and several organic acids[5], the earlier equations[1] were modified. The dissociation constant, K_c, of a complex ion $(MA_n)^c$, where M is the cation, A is the anion, n is the number of A groups relative to M, and c is the net charge on the complex ion, is

$$K_c = \frac{(A^b)^n}{(K^\circ_d/K_d) - 1}, \qquad (1)$$

in which b is the charge on the anion, K°_d and K_d are the distribution coefficients of the tracer cation between the exchanger and solution phases, in the absence and presence, respectively, of the specific anion. The distribution coefficient is defined by the equation:

$$K_d = \frac{\%\text{ of tracer in exchanger}}{\%\text{ of tracer in solution}} \times \frac{\text{volume of solution}}{\text{mass of exchanger}} = \frac{\lambda v}{m}, \qquad (2)$$

in which λ represents the per cent tracer ratio in equation (2). It is possible to measure K°_d directly or to derive it from values of K_d by graphical or analytical methods[6]. In the former case, values of $1/K_d$ are plotted against $(A^b)^n$ and the resulting straight line (for proper n values) is extrapolated to zero concentration of A, as indicated by the relation:

$$\frac{1}{K_d} = \frac{(A^b)^n}{K^\circ_d K_c} + \frac{1}{K^\circ_d}. \qquad (3)$$

The tracer, calcium-45, having a specific activity of 1·54 mC./mgm., was added to veronal buffer, which was then mixed with an isotonic saline solution containing a known concentration of the sodium salt of citric or tricarballylic acid. The mixtures of the sodium form of the cation exchanger (75 mgm.) and solution (100 ml.) were kept in glass-stoppered Erlenmeyer flasks and shaken mechanically for 2 hr. in the case of the systems containing tricarballylic acid, and 5½ hr. in those containing citric acid. In any given series of runs the ratio K°_d/K_d has been found to remain essentially constant even when the absolute values of K_d and K°_d have varied by as much as a factor of three. Ordinarily about three hours shaking-time is sufficient to give a satisfactory steady state. The β-radiations from calcium-45 were counted through a thin (2–3 mgm./cm.²) end mica-window Geiger tube. The cation exchanger was always used in the air-dried form. It had a moisture content of 18·25 per cent and contained 4·17 milli-equivalents of sodium per gram.

A 1 : 1 complex with citric and carballylic acid is formed under the conditions studied. The extrapolated values of K°_d obtained from the accompanying graph agreed with those measured directly. The value obtained for the pK_c of calcium citrate, namely, $3{\cdot}38 \pm 0{\cdot}04$, is in essential agreement with other values recorded in the literature[6–9], particularly when differences in solution composition are considered. For calcium tricarballylate, we find $pK_c = 1{\cdot}82 \pm 0{\cdot}03$. At an ionic strength of 0·1279–0·1232, Muus and Lebel[7] using one concentration of tricarballylic acid (0·005 *M*) obtained values of pK_c varying from 1·61 to 1·89.

The results show that at physiological *p*H the presence of the hydroxyl group markedly enhances the ability of citric acid to form complex ions with calcium ions. Similar results for the complex ions of strontium and radium have been obtained.

Some discussion of the factors involved in the formation of metal–organic acid complex ions was given previously[5]. It was postulated that the protons in the hydration sheath surrounding the cation tend to form linkages by hydrogen bonding with proton-accepting anions.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, November 27

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Room, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. F. Sherwood Taylor: "The Chemical Studies of John Evelyn"; Dr. D. McKie: "John Harris and his Lexicon Technicum".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. W. H. Glanville: "Road Safety and Road Research" (Cantor Lectures). (Further Lectures on December 4 and 11.)

INSTITUTION OF THE RUBBER INDUSTRY, MANCHESTER SECTION (at the Engineers' Club, Albert Square, Manchester), at 6.15 p.m.—Mr. E. Tunnicliff: "The Continuous Vulcanization of Rubber Cables".

Tuesday, November 28

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (joint meeting with the RADIO SECTION, at Savoy Place, Victoria Embankment, London, W.C.2), at 3.30 p.m. and 5.30 p.m.—Symposium of Papers on "Radiation Monitoring Apparatus".

ROYAL ANTHROPOLOGICAL INSTITUTE (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. Julian S. Huxley, F.R.S.: "New Bottles for New Wine—Ideology and Scientific Knowledge" (Huxley Memorial Lecture).

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. Stanley Robson: "Chemical Engineering Experiences in the Metallurgical and Chemical Industries" (Seventh Hinchley Memorial Lecture).

MANCHESTER GEOGRAPHICAL SOCIETY (in the Geographical Hall, 16 St. Mary's Parsonage, Manchester), at 6.30 p.m.—Mr. C. H. Bartlett: "The Canary Islands".

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Dr. A. R. Boyle: "The Measurement of Viscosity".

SHEFFIELD METALLURGICAL SOCIETY (at the Grand Hotel, Sheffield), at 7 p.m.—Mr. C. E. A. Shanahan: "A Survey of the Physical Chemistry of Sulphur in Basic Steel Making".

TEXTILE INSTITUTE, SCOTTISH SECTION (joint meeting with the EAST OF SCOTLAND SECTION of the INSTITUTION OF BRITISH LAUNDERERS, at the North British Hotel, Edinburgh), at 7 p.m.—Dr. B. P. Ridge: "The New Textiles".

Wednesday, November 29

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Right Hon. Lord Horder: "Cities without Noise".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL STATISTICAL SOCIETY, RESEARCH SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. G. E. P. Box and Mr. K. B. Wilson: "On the Experimental Attainment of Optimum Conditions".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. H. S. W. Massey, F.R.S.: "Post-War Physics".*

INSTITUTION OF ELECTRONICS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 6.30 p.m.—Mr. G. Syke: "The Beta Ray Thickness Gauge".

Thursday, November 30

INSTITUTION OF GAS ENGINEERS (joint meeting with the JOINT COMMITTEE ON MATERIALS AND THEIR TESTING, at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 10 a.m.—Discussion on "Heat Insulation".

ASLIB, NORTHERN BRANCH (in the Civic Hall, Leeds), at 10.30 a.m.—Conference.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Anniversary Meeting.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Harold Spencer Jones, F.R.S.: "Interstellar Matter". (Further Lectures on December 7 and 14.)

CHEMICAL SOCIETY, SHEFFIELD SECTION (joint meeting with the UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Lecture Theatre, The University, Sheffield), at 5.30 p.m.—Prof. M. Stacey, F.R.S.: "New Ventures in Carbohydrate Chemistry".

Friday, December 1

CHEMICAL SOCIETY, ST. ANDREWS AND DUNDEE SECTION (joint meeting with the ST. ANDREWS UNIVERSITY CHEMICAL SOCIETY, in the Chemistry Department, United College, St. Andrews), at 5 p.m.—Dr. A. F. Colson: "Micro Techniques in Chemistry".

ROYAL STATISTICAL SOCIETY, LONDON GROUP OF THE INDUSTRIAL APPLICATIONS SECTION (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Dr. G. Herdan: "Statistics of the Sieving Process".

CHEMICAL SOCIETY, MANCHESTER SECTION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY and the SOCIETY OF CHEMICAL INDUSTRY, in the Reynolds Hall, College of Technology, Manchester), at 6.30 p.m.—Mr. K. Fearnside: "The Application of Radioactive Isotopes in Industry".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Council Room, University College, Gower Street, London, W.C.1), at 8 p.m.—Dr. M. Sanai: "The Relation between Social Attitudes and Traits of Personality".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. R. H. Thouless: "Thought Transference and related Phenomena".

Saturday, December 2

BRITISH MYCOLOGICAL SOCIETY (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 12 noon.—Annual General Meeting; at 2.30 p.m.—Dr. G. C. Ainsworth: "A Century of Medical and Veterinary Mycology in Britain" (Presidential Address).

INSTITUTION OF CHEMICAL ENGINEERS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 3 p.m.—Mr. G. U. Hopton: "The Associate Membership Examination".

BRITISH INTERPLANETARY SOCIETY (in the Tudor Room, Caxton Hall, Westminster, London, S.W.1), at 6 p.m.—Mr. G. V. E. Thompson: "The Lunar Base".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN MINING ENGINEERING, and a TEACHER OF COAL-MINING, in the New South Wales Department of Technical Education—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (December 4).

SUPERINTENDENT OF THE MATHEMATICS DIVISION of the National Physical Laboratory in the Department of Scientific and Industrial Research—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3358 (December 7).

RESEARCH ASSISTANT IN THE DEPARTMENT OF CRYPTOGAMIC BOTANY—The Registrar, The University, Manchester 13 (December 8).

SCIENTIFIC OFFICERS (with a good honours degree in physics) at Ministry of Supply Research and Development Establishments mainly in the South of England, for a wide range of research and development in fundamental and applied physics—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.310/50A (December 9).

LECTURER or SENIOR LECTURER IN PHARMACOLOGY—The Registrar, The University, Leeds (December 10).

UNIVERSITY DEMONSTRATOR IN PHYSICAL CHEMISTRY—Miss J. Bird, Chemical Laboratory, Cambridge (December 14).

ELECTRONIC PHYSICISTS AND ENGINEERS (Scientific Officer grade) at Ministry of Supply Research and Development Establishments mainly in the South of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.311/50A (December 15).

PHYSICISTS AND ELECTRONIC ENGINEERS (Senior Scientific Officer or Scientific Officer grade) at a Ministry of Supply Research Establishment near London: (*a*) ELECTRICAL ENGINEER qualified in radio communications with an interest in the engineering of development prototypes, (*b*) PHYSICIST with interest in the application of electronic techniques to the solution of physical problems, (*c*) PHYSICIST for work on the application of electronic methods to photography of detonation phenomena, (*d*) PHYSICIST (good mathematical knowledge required) for experimental research on the effect of blast—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.313/50A (December 15).

LECTURER IN PHYSICAL GEOGRAPHY at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (December 16).

SENIOR LECTURERS and LECTURERS IN CIVIL ENGINEERING, ELECTRICAL ENGINEERING, MECHANICAL ENGINEERING, in the Department of Technical Education of New South Wales—The Agent-General for New South Wales, 56–57 Strand, London, W.C.2 (December 18).

RESEARCH ASSISTANTS (Grade II) IN THE INDUSTRIES DEPARTMENT of the Science Museum and the Science Museum Library—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3373 (December 21).

AGRICULTURAL RESEARCH OFFICERS (3, with honours degree in agriculture of an approved university or an equivalent qualification, and extensive knowledge of tropical or sub-tropical agriculture) in the Department of Research and Specialist Services, Southern Rhodesia—The Secretary, Office of the High Commissioner for Southern Rhodesia, 429 Strand, London, W.C.2 (December 23).

CHAIR OF ECONOMICS—The Registrar, University College of Wales, Aberystwyth (December 31).

PROFESSOR OF CHEMISTRY—The Registrar, University College, Cathays Park, Cardiff (December 31).

SENIOR LECTURER IN STATISTICAL METHODS in the Faculty of Agriculture, a SENIOR LECTURER or LECTURER IN ECONOMICS, a SENIOR LECTURER IN AGRICULTURAL CHEMISTRY, and a LECTURER IN BOTANY, at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (December 31).

SENIOR RESEARCH WORKER IN THE DEPARTMENT OF SOCIAL SCIENCE—The Registrar, The University, Liverpool (January 5).

SENIOR SCIENTIFIC OFFICER or PRINCIPAL SCIENTIFIC OFFICER, and a SCIENTIFIC OFFICER, for fundamental biological and physical research with radioactive substances—The Secretary, Marine Biological Association, The Laboratory, Citadel Hill, Plymouth (January 12).

HENRY BELL WORTLEY CHAIR OF METALLURGY—The Registrar, The University, Liverpool (January 13).

PROFESSOR OF CIVIL ENGINEERING at Canterbury University College, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (January 15).

SENIOR EXPERIMENTAL OFFICERS and EXPERIMENTAL OFFICERS—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3351 (January 31).

POSTDOCTORATE FELLOWSHIPS for research in pure chemistry and physics—The Secretary, Laboratories Awards Committee, National Research Council, Ottawa, Canada; or the Chief Scientific Liaison Officer, National Research Council of Canada, Africa House, Kingsway, London, W.C.2 (Ottawa, February 15).

I.C.I. RESEARCH FELLOWSHIPS in biochemistry, chemistry, engineering, pharmacology or physics—The Secretary, The University, Edinburgh (March 1).

ASSISTANT PHYSICIST in the Radiotherapy Department—The Secretary, Southampton Group Hospital Management Committee, Bullar Street, Southampton.

ASSISTANT SHIFT CONTROL MANAGERS (with an honours degree in chemistry or chemical engineering, associateship of the R.I.C., corporate membership of the I.C.E., or equivalent qualifications) by the Division of Atomic Energy, Sellafield, to be responsible for implementing policy and co-ordinating activities, including nuclear and chemical processes, in a large factory—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

DEMONSTRATOR IN BACTERIOLOGY—The Registrar, The University, Nottingham.

INSPECTORS OF MINES, Nigeria—The Director of Recruitment (Colonial Service), Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27099/13.

INSTRUCTORS (Demonstrators) IN ANATOMY at the Hadassah Medical School, Hebrew University of Jerusalem—The Friends of the Hebrew University of Jerusalem, 97 Baker Street, London, W.1.

JUNIOR RESEARCH OFFICER (male, with honours degree in chemistry, or equivalent) for analytical work, including development and application of analytical methods—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

LECTURER IN THE DEPARTMENT OF REFRIGERATION—The Clerk to the Governors, National College for Heating, Ventilating, Refrigeration and Fan Engineering, Borough Polytechnic, Borough Road, London, S.E.1.

PLANT GENETICIST to carry out research on the genetics of sisal at the Sisal Research Station, Tanganyika—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27059/171.

RESEARCH FELLOWSHIP IN ORGANIC CHEMISTRY—The Chemical Pathologist, Hospital for Sick Children, Great Ormond Street, London, W.C.1.

SCIENTIFIC ASSISTANT for work in connexion with the abstracting and indexing of the literature dealing with veterinary science—The Director, Commonwealth Bureau of Animal Health, Veterinary Laboratory, Ministry of Agriculture and Fisheries, New Haw, Weybridge, Surrey.

SENIOR FORECASTER (with a university degree, preferably in science, and specialized in meteorology) by the Basrah Port Directorate—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.26337/3E.

SENIOR PHYSICIST at the Hogarth Radiotherapeutic Centre—The Secretary, Nottingham No. 1 Hospital Management Committee, General Hospital, Nottingham.

TECHNICAL RECORDS ASSISTANT MANAGER (with an honours degree in chemistry, associateship of the R.I.C., or equivalent qualifications) by the Division of Atomic Energy, Capenhurst, to be responsible to the Technical Group Manager for the organization and operation of the technical records and statistical department of a large chemical engineering factory—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs.

UNIVERSITY GRADUATE IN SCIENCE, preferably with postgraduate training and 2–5 years experience in hydrodynamics or aerodynamics, and ability to apply theoretical principles to research and development problems—The Defence Research Board, Department of National Defence, Cartier Square, Ottawa, Ont., Canada; or Defence Research Member, Canadian Joint Staff, 11 Hill Street, London, W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Medical Research Council. Special Report Series No. 270: Reports on Biological Standards. 6. The Design of Toxicity Tests. By W. L. M. Perry. Pp. vi+51. (London: H.M. Stationery Office, 1950.) 1s. 6d. net. [178

Superannuation Scheme for those engaged in the National Health Service: an Explanation. Revised edition. Pp. ii+26. (London: H.M. Stationery Office, 1950.) 3d. net. [178

Northern Advisory Council for Further Education. Third Annual Report, 1949–50. Pp. 39. (Newcastle-upon-Tyne: Northern Advisory Council for Further Education, 1950.) [218

Rothamsted Experimental Station. Report for 1949. Pp. 178. (Harpenden: Rothamsted Experimental Station, 1950.) [218

British Standard 351:1950, Friction Surface Rubber Transmission Belting. Pp. 12. (London: British Standards Institution, 1950.) 2s. net. [218

British Standard 340:1950, Pre-Cast Concrete Kerbs, Channels, Edgings and Quadrants. Pp. 16. (London: British Standards Institution, 1950.) 2s. 6d. net. [228

B.I.O.S. Surveys. Report No. 28: The Fine Ceramics Industry in Germany during the Period 1939–1945. By D. A. Holdridge. (British Ceramic Research Association Special Publication No. 3.) Pp. 144. (London: H.M. Stationery Office, 1950.) 3s. 6d. net. [228

B.I.O.S. Surveys. Report No. 27: The Leather Manufacturing and Related Industries in Germany during the Period 1939–1945. By Dr. C. H. Spiers. Pp. 138. (London: H.M. Stationery Office, 1950.) 3s. 6d. net. [228

Freshwater Biological Association. Eighteenth Annual Report for the Year ending 31st March 1950. Pp. 58. (Ambleside: Freshwater Biological Association, 1950.) 2s. [248

Department of Scientific and Industrial Research: Food Investigation. Leaflet No. 6: The Refrigerated Gas Storage of Apples. By Dr. Franklin Kidd and Dr. Cyril West. Revised edition. Pp. 16. (London: H.M. Stationery Office, 1950.) 6d. net. [248

Register of Research in the Social Sciences in Progress and in Plan. (Prepared at the National Institute of Economic and Social Research, London.) No. 7: 1949–50, with a Directory of Research Institutions. Edited by Feodora Stone. Pp. 174. (London: Cambridge University Press, 1950.) 15s. [248

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 615, Vol. 234: Studies in the Post-Glacial History of British Vegetation. II. Late-Glacial Deposits in Cornwall. By Ann P. Connolly, H. Godwin and Eleanor M. Megaw. Pp. 397–469. (London: Cambridge University Press, 1950.) 19s. [248

Parliamentary and Scientific Committee. Technical Education and Skilled Man-Power. Pp. 20. (London: Parliamentary and Scientific Committee, 1950.) 1s. 3d. [298

Royal Institute of Chemistry. Lectures, Monographs and Reports. 1950. No. 3: The Synthesis of Purine Nucleotides, by Dr. James Baddiley; The Synthesis of some Natural Products by the Use of Acetylenic Precursors, by Dr. R. A. Raphael. (Third and Fourth Meldola Lectures.) Pp. 30. (London: Royal Institute of Chemistry, 1950.) 4s. net. [199

Other Countries

United States Department of the Interior: Geological Survey. Water-Supply Paper 968-D: Ground-Water Exploration in the Natchitoches Area, Louisiana. By J. C. Maher and P. H. Jones. (Contributions to the Hydrology of the United States, 1944.) Pp. iii+159–211+3 plates. 25 cents. Water-Supply Paper 1078: Ground-Water Supplies of the Ypsilanti Area, Michigan. By C. L. McGuinness, O. F. Poindexter and E. G. Olton. Pp. v+105+5 plates. 50 cents. Water-Supply Paper 1079-A: Ground-Water Resources of Liberty County, Texas. By W. H. Alexander, Jr. Pp. iv+62+1 plate. 40 cents. Water-Supply Paper 1079-B: Ground-Water Resources of Gregg County, Texas. By W. L. Broadhurst. Pp. iv+63–106. 25 cents. Water-Supply Paper 1083: Surface Water Supply of the United States, 1947, Part 3, Ohio River Basin. Pp. xiii+722. 1.75 dollars. Water-Supply Paper 1084: Surface Water Supply of the United States, 1947, Part 4, St. Lawrence River Basin. Pp. viii+287. 60 cents. Water-Supply Paper 1088: Surface Water Supply of the United States, 1947, Part 8, Western Gulf of Mexico Basins. Pp. ix+336. 65 cents. Water-Supply Paper 1091: Surface Water Supply of the United States, 1947, Part 11, Pacific Slope Basins in California. Pp. xi+450. 1.25 dollars. Water-Supply Paper 1099: Water Levels and Artesian Pressure in Observation Wells in the United States in 1947, Part 4, South-Central States. Pp. vi+201. 45 cents. Water-Supply Paper 1103: Use of Water by Bottom-Land Vegetation in Lower Safford Valley, Arizona. By J. S. Gatewood, T. W. Robinson, B. R. Colby, J. D. Hem and L. C. Halpenny. Pp. xiv+210+5 plates. 1.25 dollars. Water-Supply Paper 1105: Hydrology of Massachusetts. Part 1, Summary of Stream Flow and Precipitation Records. By C. E. Knox and R. M. Soule. Pp. viii+240+1 plate. 1 dollar. (Washington, D.C.: Government Printing Office, 1949–1950.) [17

Sveriges Geologiska Undersökning. Ser. C, No. 500: Markreationen hos sydsvenska jordar. Av O. Arrhenius. Pp. 16+6 plates. 3 kr. Ser. C, No. 501: On the Winning of Salt from the Brines in Southern Sweden. By Gunnar Assarsson. Pp. 15. 1 kr. Ser. C, No. 502: En senkvartär regressions och transgressionslagerföljd vid Halmstad. Av Carl Caldenius och Gunnel Linnman. Pp. 26. 1 kr. Ser. C, No. 504: Israndstudier i södra Bohuslän. Av Nils Björnsjö. Pp. 321+2 plates. 5 kr. Ser. C, No. 505: De geologiska resultaten från borrningarna vid Höllviken, Del 2, Undre kritan och trias. Av F. Brotzen. Pp. 48+1 plate. 2 kr. Ser. C, No. 506: De geologiska resultaten från Borrningarna vid Höllviken, Del 3, Microbotanical Studies of Cores from Höllviken, Scania. By Britta Lundblad. Pp. 17+2 plates. 1 kr. Ser. C, No. 507: De geologiska resultaten från borrningarna vid Höllviken, Del 4, On the Presence of Lepidopteris in Cores from 'Höllviken II'. By Britta Lundblad. Pp. 12+1 plate. 1 kr. Ser. C, No. 509: The Thorium Content of the Cambrian Alum Shales of Sweden. By F. F. Koczy. Pp. 12. 1 kr. Ser. C, No. 510: Notes on *Kootenia* sp.n. and associated Paradoxides Species from the Lower Middle Cambrian of Jemtland, Sweden. By Per Thorslund. Pp. 8+1 plate. 1 kr. Ser. C, No. 511: Non-Agnostidean Trilobites of the Middle Cambrian of Sweden. By A. H. Westergård. Pp. 56+8 plates. 3 kr. Ser. C, No. 512: The Titaniferous Iron-Ore Deposit of Taberg in the South of Sweden. By Sven Hjelmqvist. Pp. 55+9 plates. 3 kr. Ser. C, No. 513: Aspects to the Geochemistry of Chromium, Cobalt, Nickel and Zinc. By P. H. Lundegårdh. Pp. 56. 2 kr. Ser. C, No. 514: The Rektor Ore Body at Kiruna. By Per Geijer. Pp. 18+1 plate. 1 kr. Årsberättelse för år 1948. Pp. 8. 0.50 kr. (Stockholm: P. A. Norstedt and Söner, 1949–1950.) [21

Nyasaland Protectorate. Annual Report of the Geological Survey Department for the Year 1949. Pp. 5. (Zomba: Government Printer, 1950.) [21

Department of Agriculture, Jamaica. Bulletin No. 42: The Hope Jerseys, a Study of the Breeding of Jersey Cattle at Hope Agricultural Station, Jamaica. By T. P. Lecky. Pp. ii+62+12 plates. 1s. 9d. Bulletin No. 45: Investigations, 1948–1949. Pp. 108. 2s. (Kingston: Government Printer, 1949–1950.) [22

Liquid-Metals Handbook: a Guide to the Use of Liquid Metals as Heat-Transfer Media. Editor-in-Chief: Richard N. Lyon. Sponsored by the Committee on the Basic Properties of Liquid Metals, Office of Naval Research, Department of the Navy, in collaboration with the Atomic Energy Commission and the Bureau of Ships, Department of the Navy. Pp. viii+188. (Washington, D.C.: Government Printing Office, 1950.) 1.25 dollars. [22